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TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1930

No. 68

MILLER BROTHERS COMPANY, PETITIONER,

vs.

LEKTOPHONE CORPORATION

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE THIRD CIRCUIT

PETITION FOR CERTIORARI FILED MARCH 28, 1930

CERTIORARI GRANTED MAY 5, 1930

(34,903)

(34,903)

SUPREME COURT OF THE UNITED STATES

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UNITED STATES OF AMERICA,
DISTRICT OF DELAWARE, } *ss.:*

BE IT REMEMBERED, that at a District Court of the United States for the District of Delaware, begun and held at the United States Court House and Post Office Building, in the City of Wilmington, in said District of Delaware, at the time and place required by law, among other, the following proceedings were had, to wit:

LEKTOPHONE CORPORATION,
Plaintiff,
v.
MILLER BROTHERS COMPANY,
Defendant.
No. 712.
IN EQUITY.

DOCKET ENTRIES.

Feb. 19, 1929. Bill of complaint filed; same day subpœna issued, returnable March 11, 1929.

Feb. 21, 1929. Marshal returns on subpœna "Served," &c.; same day writ filed.

Feb. 25, 1929. Defendant appears by Wm. H. Foulk, Esqr., its solicitor; same day præcipe filed.

Mar. 6, 1929. Motion for preliminary injunction with affidavits of William H. Davis, Morton Armdt and Lester Lyon, with exhibits, filed; same day order setting motion down for hearing March 22, 1929, at 10 o'clock A. M.; affidavits to be filed by defendant on or before March 16,

1929, and by plaintiff in reply on or before March 21, 1929; same day order filed. (Exit copies to Marshal for service).

Mar. 7, 1929. Report to Commissioner of Patents mailed and copy filed.

Mar. 7, 1929. Marshal returns on copy of motion and order, "Served," &c.; same day copy filed.

Mar. 15, 1929. Order continuing hearing on motion for preliminary injunction until April 17, 1929, and for filing defendant's affidavits until April 8, 1929, and plaintiff in reply until April 15, 1929; same day order filed.

Mar. 29, 1929. Answer filed.

May 8, 1929. Stipulation filed; same day order granting leave to file amendment to answer; same day amendment filed.

May 8, 1929. Trial before Court.

May 9, 1929. Trial before Court.

May 10, 1929. Trial before Court.

May 11, 1929. Trial before Court.

May 12, 1929. Trial before Court.

May 13, 1929. Trial before Court.

May 13, 1929. Record of proceedings at trial, filed.

Oct. 14, 1929. Hearing on bill, answer and proofs.

Oct. 14, 1929. Amendment to answer, filed.

Jan. 23, 1930. Opinion of court, filed.

Feb. 12, 1930. Interlocutory decree that patent valid and infringed and that injunction issue, &c.; same day decree filed.

Feb. 12, 1930. Defendant's petition for appeal, with assignments of error filed; same

day order allowing appeal, bond in the sum of $250; same day order filed.

Feb. 12, 1930. Order staying injunction pending appeal, &c.; same day order filed.

Feb. 17, 1930. Order approving bond of defendant on appeal, in the sum of $250, with American Employers' Insurance Company as surety; same day bond filed.

Feb. 17, 1930. Citation issued.

Feb. 20, 1930. Citation, with acceptance of service by solicitor for plaintiff-appellant endorsed thereon, filed.

Feb. 28, 1930. Report to Commissioner of Patents mailed and copy filed.

Feb. 28, 1930. Stipulation as to transcript of record filed; same day order approving same; same day order filed.

Mar. 4, 1930. Stipulation as to condensed record with condensed record filed; same day order approving condensed record; same day order filed.

BILL OF COMPLAINT.

(Filed February 19, 1929.)

IN THE DISTRICT COURT OF THE UNITED STATES,
FOR THE DISTRICT OF DELAWARE.

LEKTOPHONE CORPORATION,
Plaintiff.

v.

MILLER BROTHERS COMPANY,
Defendant.

No. 712. IN EQUITY.

The plaintiff, LEKTOPHONE CORPORATION, for its bill of complaint, alleges:

1. That it is a corporation duly organized and existing under the laws of the State of Delaware, and is a resident and inhabitant of said state, having an office and place of business in Jersey City, State of New Jersey; that the defendant, MILLER BROTHERS COMPANY, is a corporation duly organized and existing under the laws of the State of Delaware, and is a resident and inhabitant of said state, and has a regular and established place of business at 900 King Street, Wilmington, Delaware, within the District of Delaware, and that the hereinafter alleged acts of infringement were committed within the District of Delaware.

2. That the jurisdiction of the Court depends upon the patent laws of the United States.

3. That prior to the fourteenth day of July, 1913, Marcus C. Hopkins was the true, original and first inventor of certain new and useful improvements in "acoustic device" not known or used by others in this

country before his invention or discovery thereof and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, or more than two years prior to his hereinafter recited application for letters patent therefor, and not in public use or on sale in this country for more than two years prior to his said application and for which no application for letters patent in any country foreign to the United States of America had been filed more than twelve months prior to the filing of the application in this country, and which had not been abandoned; that being entitled to a patent for said improvements under the provisions of the statutes of the United States then in force, the said Marcus C. Hopkins did, on the fourteenth day of July, 1913, file in the Patent Office of the United States an application for letters patent on said invention, which application was subsequently divided and a divisional application thereof filed on the seventeenth day of April, 1918; that said divisional application was duly assigned to the plaintiff, LEKTOPHONE CORPORATION, before the issuance of said letters patent by mesne assignments duly recorded in the Patent Office; that thereafter, to wit, on the second day of July, 1918, all of the requirements of the statutes then in force having been complied with, letters patent of the United States for said invention, signed, sealed and executed in due form of law, were duly issued and delivered to the said LEKTOPHONE CORPORATION, as assignee of the entire right, title and interest therein and thereto; that the letters patent so issued was No. 1,271,529 and said letters patent or a duly certified copy thereof is ready to be produced in court.

4. That the plaintiff is now and has been ever since the issuance of said letters patent, the owner, subject to certain non-exclusive licenses, of all right, title and

interest in and to said invention and in and to said letters patent No. 1,271,529.

5. That the plaintiff and its licensees, since the date of said invention have caused to be manufactured and sold acoustic devices embodying the invention of said letters patent and have spent large sums of money in causing said invention to be developed and have built up a large and profitable business for the exploitation of said acoustic devices. That plaintiff's ownership of said invention and letters patent has been widely recognized and acquiesced in by the public and by the trade and that said invention and patent rights have been and are of great utility and great value to the plaintiff and to its licensees, and, but for the unlawful acts of the defendant herein complained of, would have been of greater value and profit to them.

6. That prior to and since the acts complained of, said acoustic devices manufactured and sold by plaintiff and its licensees have been duly marked "Patented" together with the date and year in which said letters patent were granted, all in the manner prescribed by the statutes of the United States; that the defendant has been duly notified of its infringement of said letters patent, but notwithstanding said notice, continues said infringement, whereby the defendant has profited and the plaintiff has been damaged.

7. That well knowing the premises, the defendant has, since the grant of said Letters Patent No. 1,271,529, and prior to the filing of this bill of complaint, infringed upon said letters patent and plaintiff's right thereunder, by selling, within the District of Delaware, without right or license, loud speakers embodying the invention of said letters patent; and as an instance of said infringement the plaintiff alleges that prior to the filing of this bill of complaint, and since the

grant of said Letters Patent No. 1,271,529, defendant has sold, without right or license, at its place of business, 900 King Street, Wilmington, Delaware, within the District of Delaware, so called "Fada" loud speakers, known as Models 14B and 15B, embodying the invention of said Letters Patent No. 1,271,529.

WHEREFORE, plaintiff prays:

1. For an injunction, and a preliminary injunction pending this suit, prohibiting the defendant, MILLER BROTHERS COMPANY, its agents and employees, from directly or indirectly making or causing to be made, using or causing to be used, selling or causing to be sold, acoustic devices embodying the invention of said Letters Patent No. 1,271,529, and from infringing upon or violating the rights of the plaintiff under said letters patent in any way whatsoever.

2. For costs and an accounting of profits and damages, and that upon rendering a decree herein, the actual damages be trebled in view of the wilful infringement by the defendant.

3. For such other and further relief as the circumstances of the case may require.

LEKTOPHONE CORPORATION,

(Sgd.) ROBERT DAVIS,
President.

(Sgd.) JOHN F. NEARY,
Solicitor for Plaintiff.

(Sgd.) WILLIAM H. DAVIS,
Of Counsel.

STATE OF NEW YORK,
COUNTY OF NEW YORK, } *ss.:*

ROBERT DAVIS, being duly sworn, deposes and states that he is the president of LEKTOPHONE CORPORATION, the plaintiff named in the foregoing bill of complaint; that he has read and understood the same and knows the contents thereof, and that the same is true of his own knowledge, except as to the matters therein stated to be on information and belief, and that as to those matters, he believes it to be true.

(Sgd.) ROBERT DAVIS.

Sworn to and subscribed before me this sixteenth day of February, 1929.

(Sgd.) E. H. BARRETT,
Notary Public.
Notary Public New York County.
N. Y. Co. Clk.'s No. 78 Reg. No. 0-22.
Commission expires March 30, 1930.

ANSWER AS AMENDED.*

(Filed March 29, 1929.)

The defendant, for answer to the bill of complaint herein, says:

1. Defendant denies each and every allegation contained in paragraph 3 of the bill of complaint, except that it admits having seen what purported to be a copy of Letters Patent No. 1,271,529, issued to plaintiff on July 2, 1918, on an application filed April 17, 1918.

2. Defendant has no information sufficient to form a belief as to matters set forth in paragraph 4 of the bill of complaint and therefore denies the same.

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*Amendments filed May 8, 1929, and October 14, 1929.

3. Defendant denies each and every allegation contained in paragraph 6 of the bill of complaint.

4. Defendant denies each and every allegation contained in paragraph 6 of the bill of complant.

5. Defendant denies each and every allegation contained in paragraph 7 of the bill of complaint.

6. Defendant specifically denies that it has infringed the said Hopkins Patent No. 1,271,529.

7. Further answering the bill of complaint, defendant alleges on information and belief that the said Hopkins Patent No. 1,271,529 is void and invalid at law for each of the following reasons:

(a) Because the alleged invention thereof has been shown and described in printed publications prior to the alleged invention thereof by the said Hopkins, or more than two years prior to his application for letters patent, among others by the following:

UNITED STATES PATENTS.

Lumiere	No.	986,477
Lumiere	"	1,036,529
Edison	"	963,362
English	"	1,064,062
Lumiere	"	1,072,477
Hogan	"	632,015
Head	"	805,544
Elfering	"	1,182,078
Kraemer	"	890,142
Burch	"	1,506,160
Dann & Lapp	"	338,660
Maxwell	"	216,051
English	"	1,192,289

BRITISH PATENTS

Asam	No. 152,955	of 1903
Lodge	" 9,712	" 1898
Stroh	" 9,418	" 1899
Stroh	" 3,393	" 1901
Brown	" 1,157	" 1911
Brown	" 29,833	" 1910

FRENCH PATENTS.

Gaumont	No. 331,226	of 1903
Ader	" 127,180	" 1878

Article by Starling and Cole in the issue of "Talking Machine News" for July, 1907.

(b) Because of lack of invention in view of the state of the art at the time the alleged invention was made, the state of the art being represented by the publications set forth in paragraph (a) hereof.

(c) Because the patentee Hopkins was not the first inventor of the alleged invention or discovery forming the subject matter of the said Hopkins patent, nor of any substantial or material part thereof, but the same was invented by Jackson L. Waite, of Cleveland, Ohio, at Middletown, Ohio, before the alleged invention or discovery by the said Hopkins.

(d) Because the alleged invention forming the subject matter of the said Hopkins patent was in public use and/or sale before the alleged invention or discovery thereof by the patentee, Hopkins, or more than two years prior to the application for the said Hopkins patent, those knowing of or participating in the said public knowledge, use and/or sale being as follows:

Jackson L. Waite, of Cleveland, Ohio, at Middletown, Ohio;

Alfred B. Wertz, of and at Middletown, Ohio;

Daniel B. Imfeld, of and at Middletown, Ohio;
Dr. W. B. Ligett, of and at Middletown, Ohio;
William E. Watson, of and at Middletown, Ohio;
Etta H. Waite, of and at Middletown, Ohio;
Dr. S. C. Ligett, of and at Lake Worth, Florida;

and perhaps others whose names and addresses defendant is not at present advised.

(e) Because the said patent was not applied for within two years subsequent to the first allowance of the subject matter thereof as required by Section 4897 R. S.

WHEREFORE defendant denies that plaintiff is entitled to the relief prayed for, or to any relief, and therefore prays to be hence dismissed with its costs in this cause sustained.

MILLER BROTHERS COMPANY,
By (Sgd.) WM. H. FOULK,
Its Attorney.

(Sgd.) WM. H. FOULK,
Solicitor for Defendant,
Room 4014, DuPont Building,
Wilmington, Del.

(Sgd.) SAMUEL E. DARBY, JR.,
Of Counsel,
220 Broadway, New York, N. Y.

Dated: Wilmington, Del.,
March 29, 1929.

OPINION OF THE COURT.

(Filed January 23, 1930.)

F. A. D. Andrea, Inc., of New York, manufactures radio loud speakers in two sizes. Instruments of each size were sold by Miller Brothers Company of this State. Thereupon Lektophone Corporation, the owner of Hopkins patent No. 1,271,529 instituted this infringement suit in equity against Miller Brothers Company charging that the sale of the smaller instrument infringed claims 4 and 8 and the sale of the larger infringed all the claims of that patent.

This patent has been considered by various courts including the Circuit Court of Appeals for this Circuit in Lektophone Corp. v. Brandes Products Corp., 20 Fed. (2d) 155. There has been much diversity of judicial opinion with respect to it. But in the Brandes case, the patent was sustained and the scope of the claims ruled upon. The orderly administration of justice requires that matters decided by the Circuit Court of Appeals of any Circuit have a binding effect upon all the District Courts in that Circuit, notwithstanding contrary decisions in other Circuits. Edison Electric Light Co. v. Bloomingdale, 65 Fed. 212. Such matters include the validity and construction of Letters Patent, where the evidence pertinent to such issues are the same. National Folding Box & Paper Co. v. American Paper Pail & Box Co., 48 Fed. 913; Bowers Dredging Co. v. New York Dredging Co., 80 Fed. 119; and, by analogy, Westinghouse Air Brake Co. v. Christensen Engineering Co., 113 Fed. 594; Birmingham Cement Manufacturing Co. v. Gates Iron Works, 78 Fed. 350 (C. C. A. 5); American Bell Tel. Co. v. Southern Tel. Co., 34 Fed. 795. Consequently, without regard to the effect that should be given under the rules of comity by the courts of one Circuit to a decision upon the same

patent by the courts of another Circuit, Mast, Foos & Co. v. Stover M'f'g Co., 177 U. S. 485; Rousso v. First Nat. Bank, 19 Fed. (2d) 247, it is both clear and settled that when a patent has been sustained and construed by the Circuit Court of Appeals of a Circuit, a District Court of the same Circuit subsequently dealing with the same patent even in a suit between different parties must first inquire whether the second record contains anything not before the Appellate Court. If it finds therein nothing new, the earlier decision of the Appellate Court must be accepted as controlling. If something new is discovered, the District Court must next inquire whether the new matter is of such character that it may be fairly supposed that the Appellate Court would have reached a different conclusion had the new facts been before that Court. It cannot be so supposed unless the new matter is clear, substantial and reasonably conclusive. Moreover, the controlling effect of the decision of the Appellate Court is not limited to the facts and defenses discussed in its opinion but extends to all that were before it in the record. Badische Anilin & Soda Fabrik v. A. Klipstein & Co., 125 Fed. 543; Conley v. Thomas, 204 Fed. 93; Flat Slabs Patents Co. v. Wright, Barrett & Stilwell Co., 283 Fed. 345; Rose v. Fretz, 98 Fed. 112; Electric Manuf'g Co. v. Edison Electric Light Co., 61 Fed. 834 (C. C. A. 7); Carson Inv. Co. v. Anaconda Copper Mining Co., 26 Fed. (2d) 651, 657 (C. C. A. 9).

The evidence in the case at bar differs in no substantial particular from that in the Brandes case. Hence, the decree of this Court, in the pending case, must be dictated by the decision of the Circuit Court of Appeals in the Brandes case unless the defense, here made for the first time, under R. S. 4897 is sound.

That section provides in part:

> "Any person who has an interest in an invention or discovery, whether as inventor, discoverer,

> or assignee, for which a patent was ordered to issue upon the payment of the final fee, but who fails to make payment thereof within six months from the time at which it was passed and allowed, and notice thereof was sent to the applicant or his agent, shall have a right to make an application for a patent for such invention or discovery the same as in the case of an original application. But such second application must be made within two years after the allowance of the original application."

The original application, filed July 14, 1913, was allowed April 11, 1916, but the final fee was not paid within six months from such allowance. On March 22, 1918, twenty days less than the two-year statutory period, the second or renewed application was filed. Six days later an amendment was filed cancelling claims 25, 26 and 27 with the statement that those claims had "been cancelled, as those claims will be incorporated together with others, in a divisional application directed to the tympanum or diaphragm per se." The divisional application resulting in the patent in suit was filed April 17, 1918, or six days more than two years after the allowance of the original application. The specification of the patent in suit states that the invention thereof "is to be considered as a division of the invention shown and described in my prior application, renewed March 22, 1918."

In support of its contention that the divisional application was invalidated by R. S. 4897, defendant relies upon Chapman v. Wintroath, 252 U. S. 126; Western Electrical Instrument Co. v. Empire Electrical Instrument Co., 136 Fed. 599 (C. C. A. 2) and Dwight & Lloyd Sintering Co. v. Greenawalt, 27 Fed. (2) 823, 831 (C. C. A. 2). These cases do not, however, in my opinion sustain defendant's view. They contain nothing, particularly when read in connection with Webster Co. v. Splitdorf Co., 264 U. S. 463; American

Laundry Machinery Co. v. Prosperity Co., 295 Fed. 819 (C. C. A. 2); Diamond Power Specialty Corp. v. Bayer Co., 13 Fed. (2d) 337 (C. C. A. 8); Wagenhorst v. Hydraulic Steel Co., 27 Fed. (2d) 27 (C. C. A. 6), that denies to the divisional application, which was filed promptly after the filing of the unchallenged renewed application and contained no new matter, the valid status of the renewed application.

The plaintiff is entitled to the relief it seeks.

(Sgd.) HUGH M. MORRIS, *J.*

January 23, 1930.

INTERLOCUTORY DECREE.

(Filed February 12, 1930.)

This cause having come on to be heard at final hearing upon the pleadings and proofs taken and filed on behalf of both parties herein and counsel for the respective parties having been heard and due consideration having been had, it is, upon motion of John F. Neary, solicitor for plaintiff.

ORDERED, ADJUDGED and DECREED as follows:

1. That Letters Patent of the United States, No. 1,271,529, issued to Marcus C. Hopkins on July 2, 1918, for acoustic devices, are good and valid in law as to all of the claims thereof.

2. That the said Marcus C. Hopkins was the true, original, first and sole inventor of the invention and improvement described in said Letters Patent No. 1,271,529 and defined in the claims thereof.

3. That the plaintiff, Lektophone Corporation, is the lawful, sole and exclusive owner of the entire

right, title and interest arising from and under said Letters Patent No. 1,271,529.

4. That the defendant, Miller Brothers Company, has infringed upon all of the claims of said Letters Patent No. 1,271,529, and the exclusive rights of the plaintiff therein and under the same by selling and using and causing to be sold and used without right, license or consent of the plaintiff, acoustic devices containing, employing and embodying the invention and improvement described and claimed in said letters patent.

5. That a perpetual injunction issue out of and under the seal of this Court directed to and prohibiting, enjoining and restraining the defendant, Miller Brothers Company, its officers, associates, attorneys, directors, clerks, agents, workmen and employees, and every person acting for or on behalf of said defendant, and each of them, from directly or indirectly making or causing to be made, using or causing to be used, selling or causing to be sold or attempting, offering, negotiating for or encouraging the manufacture, use or sale of any or all apparatus embodying the invention of claims 1 to 8 inclusive of said Letters Patent No. 1,271,529, and from infringing upon or violating the rights of the plaintiff under said letters patent in any way whatsoever.

6. That the plaintiff, Lektophone Corporation, do recover of the defendant, Miller Brothers Company, the profits, gains and advantages that it has derived, received, earned or made, or that it shall derive, receive, earn or make by reason of the aforesaid infringement, and that the plaintiff do recover of the defendant any and all damages that the plaintiff has sustained or shall sustain by reason of said infringement, the account to be taken and stated and the dam-

age to be assessed by proceedings appropriated for such purposes hereinafter to be taken.

7. That the plaintiff do recover from the defendant its costs and disbursements in this suit to be taxed, and that all further questions be reserved until the coming in of the Master's report.

(Sgd.) HUGH M. MORRIS,
Judge.

Dated, February 12, 1930.

Approved as to form.

(Sgd.) WM. H. FOULK,
Solicitor for Defendant.

DEFENDANT'S PETITION FOR APPEAL.

(Filed February 12, 1930.)

The above-named defendant, Miller Brothers Company, conceiving itself aggrieved by the decree made and entered on the twelfth day of February, A. D. 1930, in the above-entitled cause, does hereby appeal from said order and decree to the United States Circuit Court of Appeals for the Third Circuit for reasons specified in the assignment of error which is filed herewith and it prays that this appeal may be allowed and that the transcript of the record, proceedings and papers upon which said decree was made, duly authenticated, may be sent to the United States Circuit Court of Appeals for the Third Circuit.

(Sgd.) WM. H. FOULK,
Solicitor for Defendant.

ORDER ALLOWING APPEAL.

(Filed February 12, 1930.)

AND NOW TO WIT, this twelfth day of February, A. D. 1930, upon consideration of the foregoing petition for appeal in the above-entitled cause, it is upon motion of William H. Foulk, Esquire, solicitor for the petitioner,

ORDERED BY THE COURT that the appeal of said defendant prayed for therein, be and hereby is allowed and the amount of the appeal bond to be entered by the appellant is hereby fixed in the sum of two hundred and fifty dollars ($250).

(Sgd.) HUGH M. MORRIS, *J.*

DEFENDANT'S ASSIGNMENT OF ERRORS.

(Filed February 12, 1930.)

Now comes the above-named Miller Brothers Company, by its solicitor, William H. Foulk, Esquire, and files the following assignment of errors upon which it will rely in its appeal herein to the United States Circuit Court of Appeals for the Third Circuit as follows:

1. The District Court erred in granting an injunction.

2. The District Court erred in decreeing Hopkins' patent to be valid.

3. The District Court erred in decreeing any and all of the claims of the Hopkins' patent were infringed by the defendant.

4. The District Court erred in refusing to dismiss the bill of complaint.

5. The District Court erred in failing to hold that the Hopkins' patent was invalid under Section 4897 R. S.

6. The District Court erred in refusing to consider the merits of the case in view of the prior decision of the Court of Appeals for the Third Circuit involving a different infringing structure of a different defendant.

(Sgd.) Wm. H. Foulk,
Solicitor for Defendant.

CITATION.

(Filed February 20, 1930.)

United States of America, *ss.:*

The President of the United States,

To Lektophone Corporation, a corporation organized and existing under the laws of the State of Delaware,

Greeting:

You are hereby cited and admonished to be and appear in the United States Circuit Court of Appeals for the Third Circuit, in the City of Philadelphia, State of Pennsylvania, on the eighteenth day of March, A. D. 1930, pursuant to an appeal taken in a case pending in the District Court of the United States for the District of Delaware, wherein Miller Brothers Company is defendant-appellant, and you are plaintiff-appellee, to show cause, if any there be, why the decree rendered against the said Miller Brothers Company, defendant-appellant, should not be cor-

rected and why speedy justice should not be done to the parties in that behalf.

Witness my hand, at Wilmington, in said district, this seventeenth day of February, A. D. 1930.

(Sgd.) HUGH M. MORRIS,
United States District Judge,
District of Delaware.

Service of the foregoing citation, with copy, accepted this nineteenth day of February, A. D. 1930.

(Sgd.) JOHN F. NEARY,
Solicitor for Plaintiff-Appellee.

PROCEEDINGS AT TRIAL.

IN THE UNITED STATES DISTRICT COURT,
FOR THE DISTRICT OF DELAWARE.

LEKTOPHONE CORPORATION,
Plaintiff,
v.
MILLER BROTHERS COMPANY,
Defendant.

No. 712.
IN EQUITY.

In the U. S. District Court,
Wilmington, Delaware,
Wednesday, May 8, 1929,
10 o'clock A. M.

Before: HON. HUGH M. MORRIS, U. S. District Judge.

Appearances: Messrs. PENNIE, DAVIS, MARVIN & EDMONDS (N. Y. City) by WILLIAM H. DAVIS, ESQ.; HENRY T. HUNT, ESQ. (New York City); JOHN F. NEARY, ESQ., of Counsel for plaintiffs.

SAMUEL E. DARBY, JR., ESQ. (Messrs. Darby & Darby, New York City); G. WILLARD RICH, ESQ. (Messrs. Williams, Rich & Morse, New York City); WILLIAM H. FOULK, ESQ. (Wilmington, Delaware), of counsel for defendants.

Plaintiff's Proofs.

MR. DAVIS: I offer in evidence a certified copy of the file wrapper and contents of the application which resulted in Patent No. 1,271,529 as Exhibit 1.

(Received in evidence and marked "Plaintiff's Exhibit No. 1.")

MR. DAVIS: And a certified copy of the file wrapper and contents of the application which resulted in Patent No. 1,271,527 and which was the parent application as Exhibit No. 2.

(Received in evidence and marked "Plaintiff's Exhibit No. 2.")

MR. DAVIS: I offer in evidence as Exhibit 3—will you stipulate that these were bought in the open market from Mr. Miller within the period?

MR. DARBY: If you tell me that that is the fact I certainly will stipulate it.

MR. DAVIS: That is the fact. There is an affidavit on record to that effect and the young man is here who bought them.

MR. DARBY: I will stipulate it.

MR. DAVIS: I offer in evidence as Exhibit 3 a radio loud speaker which is of the smaller size and it is agreed that this loud speaker was bought from the defendant, just as it is, prior to the filing of the bill of complaint and since the issuance of the patent.

MR. DARBY: For the purposes of identification, Mr. Davis, I think this small size speaker is known as No. 15 and the larger size is known as No. 14.

MR. DAVIS: This was marked 15-B.

MR. DARBY: That is right.

MR. DAVIS: The speaker being identified by the No. 15-B.

(Received in evidence and marked "Plaintiff's Exhibit No. 3.")

MR. DAVIS: I offer in evidence as Exhibit 4 a second loud speaker identified as 14-B of larger size and it is likewise stipulated that this speaker was sold by the defendant prior to the filing of the bill and since the issuance of the patent.

THE COURT: The only difference with which you are here concerned being that of size.

MR. DAVIS: Yes.

(Received in evidence and marked "Plaintiff's Exhibit No. 4.")

MR. DAVIS: If the Court please, I have a printed copy here of the record in the Brandes case which I should like to leave with the clerk because there will be occasion to refer to it. I see no occasion to put it in evidence.

THE COURT: Then just let it be marked for identification without being offered in evidence.

(The same was marked "Plaintiff's Exhibit A for Identification.")

MORTON ARENDT.

MORTON ARENDT, called as a witness in behalf of the plaintiff, having been duly sworn, testified as follows:

DIRECT EXAMINATION BY MR. DAVIS:

I was trained in the public schools of the City of New York, studied for the bachelor of science degree at the College of the City of New York and graduated from the Columbia University with the degree of electrical engineer in 1898. From that date on I have practiced my profession in its various branches.

My present position is one of the professors of the Electrical Engineering Department of Columbia University. I have had experience in the designing of machinery practically all my life. I have designed electrical machinery for many manufacturing companies, designed electrical equipment for the United States Government.

With regard to having specialized in acoustics, I have not done so excepting in so far as it entered into my professional activities as for instance in advising the Bosch Corporation cooperating with the Dictagraph Products Corporation and in developing or cooperating in the development of the submarine signaling apparatus on United States submarines.

The occasion of developing that signaling apparatus was, I was connected with the United States Government as a commander in the United States Navy. I was in charge of and organized the electrical school for naval officers in 1917 and was in active charge of the electrical division of that school for a year, after which I was made technical aide to all submarine bases on the east coast and flotillas on the east coast, in the course of which problems in the development of listening apparatus were sent to me as to many other technical men throughout the country.

My work was in connection with the so-called oscillator, whereby you exchange the frequency of tones from time to time so as to vary general recognition of a vessel out at sea. I have lectured since 1902 at Columbia University in electrical communications, which naturally includes transmission and receiving apparatus.

I have read the patent here sued on and have examined two defendant's devices, Exhibits 3 and 4.

I had the drawings I now produce made under my direction by a draughtsman employed by Mr. Davis's

firm, and the drawing represents a plan view of the front of the "Fada" 15-B and 14-B loud speakers. I have given no dimensional values on the drawings themselves, but have lettered various dimensions and then later given their exact values.

Figure 2 of this sheet represents a sectional drawing, through either or both of the Fada loud speakers, wherein are indicated by letters the height of the theoretical cone from which this frustrum is obtained, the height of the frustrum, the diameter of the conical portion of the tympanum, and the outside dimensions of the tympanum where it is secured to a ponderous ring. The values in numerical figures for the smaller unit are given under "small speaker." *a* represents the diameter of the outside of the tympanum, which is eight inches wide. *b* represents the diameter of the conical portion of the tympanum. *c* represents the width of the annular portion of the tympanum which connects the conical portion to the rim.

e represents the height of the cone on which this structure was developed; and *d* represents the effective height of the truncated portion. The corresponding letters under the large speaker indicate the same portions. *f* indicates the angle between the sloping sides of the cone and the base, which, in the case of the small speaker is thirty-eight degrees, and in the case of the larger speaker is forty-three degrees.

The assertion that is printed on the drawing is as follows:

"The angle *f* of a cone whose altitude is one-quarter of diameter of its base is 26 degrees 34 minutes."

Directing my attention to the figure of the drawing of Patent No. 1,271,629 and particularly to the plane peripheral rim portion marked *l* on the question, what effect the width of that portion has upon

the flexibility of the support of the central conical portion, I would say if the width of *l* were made greater, that it would become more flexible. If it were shortened, it would naturally become stiffened, if of the same material.

THE COURT: *l* is what?

THE WITNESS: That is the rim portion which was here (indicating).

THE COURT: I got that; it is the rubber band in the Brandes?

THE WITNESS: It is the rubber band, yes, in the Brandes device.

THE COURT: In the Brandes device, yes.

THE WITNESS: Now, directing attention to lines 127 and following on page 2 of the patent specification, where the patentee says:

"Yet it is possible to form radial or concentric corrugations in the plane peripheral portion *l*."

On the question of what would be the effect of forming radial corrugations in the plane peripheral portion, they would naturally stiffen.

The effect of forming concentric portions in the plane peripheral portion would be that they would naturally lengthen it or produce greater flexibility.

MR. DAVIS: I now offer in evidence as Plaintiff's Exhibit 5 the sheet of drawings to which the witness has referred.

(Received in evidence and marked "Plaintiff's Exhibit No. 5.")

CROSS-EXAMINATION BY MR. DARBY:

XQ. 17. I can tell you that we agree with all of your measurements with the exception of perhaps two.

Your measurement *e* of both the large and small, which extends from the front edge of the cone to the apex of the cone if there was an apex, I find our measurements with the small speaker it is 2.867 inches as against your 2¾ inches, and I find that with the large speaker it is 4¼ inches instead of 4 inches, as you have it there. I would like to have you check that up again, if you will, please.

A. I shall be very glad to do so, sir.

XQ. 18. And likewise in Figure 2 of your drawing, I would like to have you give me the measurements for both the large and the small cone of the edge metal ring (indicating) or at least have you check up my measurements?

A. I would be very glad to check that from your drawings.

XQ. 19. And have you check up my measures on that in the large cone. My measurements are 8.250 inches and the small cone is 6.75 inches.

A. I have no such dimensions on my drawing.

XQ. 20. I know it.

A. Therefore I cannot check them.

XQ. 21. I merely wanted to get them on the drawing. Will you do that now, please, sir?

MR. DAVIS: I will have marked for identification this loud speaker of Brandes which is a replica of the larger one that was before the Court of Appeals in the Brandes case. Please mark that as larger Brandes loud speaker, and the second one, the smaller one, will be marked for identification as the smaller one.

(Received and marked "For identification Plaintiff's Exhibits B and C" respectively.)

THE COURT: You have the smaller one. So the large speaker which is Plaintiff's Exhibit for

Identification B, was that before the Court of Appeals?

MR. DAVIS: Yes, your Honor.

THE COURT: They were both before them?

MR. DAVIS: They were both before the Court of Appeals. It was precisely as it is here. They had one larger than nine inches and one that was smaller than nine inches.

THE COURT: I see.

MR. DAVIS: If the Court please, that is our *prima facie* case.

Defendant's Case.

DAYTON C. MILLER.

DAYTON C. MILLER, was called as a witness on behalf of the defendant, and being first duly sworn, testified as follows:

DIRECT EXAMINATION BY MR. DARBY:

I am sixty-three years; reside at Cleveland, Ohio, and I am Swasey Research professor of physics in Case School of Applied Science.

I had my first college training at the College at Ohio; took graduate course of study in physics and mathematics at Princeton University, securing the degree of doctor of science in 1890. Since that time I have been connected with the Case School of Applied Science, in Cleveland. I was for more than thirty years in charge of the Department of Physics of that institution, and at present have the title of Swasey Research professor of physics.

I have always been interested in music from my childhood, playing instruments and studying the history and science of instruments. In my professional work at the college, it has been a part of the laboratory experimentation to study the construction and properties of musical instruments of all kinds.

I have been especially interested in the phonograph and talking machine since its start. I have been directly connected in an experimental way with wireless and radio since the beginning.

I have been employed as expert adviser to a number of manufacturers of musical instruments, principally in relation to talking machines, sound-boxes and horns, and radio loud speakers and other musical instruments, and as to scientific societies, I am a member of the National Academy of Science, and the American Philosophical Society and the Acoustical Society of America and the American Physical Society. I can name others; there are twenty-six of them in all.

I am the author of quite a large number of scientific papers dealing with the subject of acoustics and sound, loud speakers, horns, and so forth; and I gave a course of eight lectures at the Lowell Institute in Boston entitled, "The Science of Musical Sounds," which later resulted in the publication of a book of that title.

I have had specimens of these two instruments of the Fada manufacture, Plaintiff's Exhibits Nos. 3 and 4, in my college laboratory for weeks. I have experimented with them and used them in radio reception, and I have had them in my home, using them in radio reception.

I am familiar with Hopkins Patents Nos. 1,271,527 and 1,271,529; I have known them for some years previous to this case, and studied them previously, as well as now.

Referring to the parent patent No. 1,271,527, which was the patent which was issued on the parent application, page 1, line 13:

> "This invention relates to instruments which reproduce sounds, such as the talking machine and the phonograph, and is particularly directed to the attainment of a direct propagation in free air from a record of self-sustaining sound waves substantially corresponding to the original recorded sounds in intensity or amplitude as well as in pitch and timbre," and so forth.

I understand from this language that it means the type of record used on talking machines and phonographs at the time the patent was issued, which consisted of records made in the form of discs, some of them made in the form of cylinders, in the earlier days, in which there are indentations in the material which caused the needle to move back and forward or up and down in such a way as to reproduce the sounds.

In reproduction of broadcast speech or music, there is no record in the sense here intended.

There is nothing recorded which a loud speaker, a radio loud speaker reproduces in the ordinary operation.

I next call attention to the language of the specification on page 1, lines 72 to 78, as follows:

> "It is an object of the present invention to regenerate the recorded sounds directly from the record, without the interposition of a confined body of air and without the employment of a restrictive transformer, such as a horn."

On the question of whether or not there is anything in a radio receiving system or even including the radio transmitting system, of a speaker or an

orchestra, corresponding to a record or recorded sound directly from which the loud speaker in a radio receiving set secures its actuating impulses, I would say that there is no material record. That is to say there is nothing recorded, permanently recorded in the radio system.

I next call attention to page 2, line 7:

> "I have illustrated in the accompanying drawings a sound reproducing machine embodying the several novel features of the invention as they may be employed in regenerating sounds from records made with either laterally or vertically sinuous grooves."

That refers, of course, to a phonograph record.

Phonograph records of two types were in use at that time and are to some extent today.

I was familiar with the phonograph art, between the years 1910 to 1914.

At that time I was serving as expert for one of the principal makers of talking machines, namely The Aeolian Company of New York, makers of the Vocalion talking machine.

As to the reproduction power of phonographs, phonograph records, as of 1910 to 1914, as compared to present-day phonograph records, there have been improvements in methods of recording and in methods of manufacture, so that the records of the present day are capable of delivering considerably more power than the records of fifteen years ago.

It might be as much as five or ten times as much power, so that a louder reproduction can be obtained today than was available at that time. That is the improvements have been in various parts of the reproducing apparatus, and in the records also.

In the science of acoustics the sound sensation is generated in the air by what we call the energy of the

sound wave, which consists essentially of condensations and rarefactions in the air impinging upon the tympanum of the ear. This energy is transmitted in the sound waves from the source, whatever that source may be, and the loudness of the sound varies in a general way with the energy contained in this wave. It varies with the amplitude and frequency of the vibrations.

With respect to the degree of loudness of any particular sound, that depends upon the energy which consists in those condensations and rarefactions, and is dependent upon amplitude and frequency.

That is to say that the compressions and rarefactions depend for their amount upon the amount of energy and that can be properly translated into terms of power.

In reproducing from a phonograph record, if the stylus needle moves just a very little bit—confining our discussion to power—you would expect a sound that would not be as loud as if the needle vibrated a greater distance, other things being equal.

On the question of pitch, the frequency of vibration determines pitch.

And if the vibration is slow the pitch would be low. If it vibrates very rapidly, it would be a high pitch.

In the phonograph art in 1910 to 1914, there was a practical limitation as to the minimum frequency that played substantial part in both the recording or reproduction.

In both recording and reproduction, the lower frequencies were recorded with less intensity in proportion to the higher ones, and sometimes with a very low intensity, in comparison with the higher notes. By low intensity, I mean as compared with the original sound, which was being recorded, it was not re-

corded in a properly balanced form, and the same was largely true of the reproducers that reproduce the higher frequencies; I mean from 200 up perhaps, reproduced those better in a more accurate manner than they did the lower frequencies.

That is true in a very much less degree today than it was before. There have been very great improvements in that respect, so that the lower sounds are recorded and reproduced in a more nearly proper proportion though not yet perfect in most cases.

I am familiar with the paper of J. P. Maxfield and H. C. Harrison, entitled, "Methods of High Quality Recording and Producing of Music in Speech, Based on Telephone Research."

They are gentlemen of good standing in the scientific and engineering field.

In this paper is a drawing designated Figure 20, appearing on page 252, entitled as follows:

> "Response frequency characteristic of two phonographs, curve A shows the characteristic of the band pass filter type described. Curve B shows the characteristic of one of the best commercial machines previously on the market."

This curve indicates in A the characteristic of the band pass filter type described in this paper, and it shows that frequencies above, about 115 up to frequencies of 4000 and more, are passed with uniform facility. The curve has what may be described in general as a flat top, these different frequencies being transmitted in about equal proportions as they ought to be when diagrammed in this manner.

Curve B, representing the commercial machines previously on the market, shows that such machines transmit very little energy, none at all, according to this curve, about frequencies lower than 240. Above

that frequency, up to 4000 and over, the transmission is more irregular than that shown by the curve A. That is in accordance with the statement made in a previous answer that the earlier machines did not transmit the lower frequencies in the desired proportion.

The results there shown are in conformance with my experience. I have experimentally observed the same conditions as are shown in these curves.

MR. DARBY: I offer in evidence the paper of Maxfield & Harrison entitled "Methods of High Quality Recording and Reproducing of Music in Speech, Based on Telephone Research," appearing in March, 1926, paper, the same being an abridgement of the paper presented in the mid-winter convention of the A. I. E. E., New York, February 8 to 11, 1926, referring particularly to page 252.

MR. DAVIS: I object to the admission of the paper for any other purpose than as identifying the witness's testimony.

MR. DARBY: That is the only purpose for which it is offered.

(Paper received in evidence and marked "Defendant's Exhibit No. 7.")

THE WITNESS: As to the amount of power available to vibrate a sound reproducer from a phonograph record in 1910 and 1914, as compared to the amount of power available to vibrate a sound reproducer in a radio loud speaker of today, I have this to say, the present-day radio loud speaker, using the amplifiers that are ordinarily provided in the receiving sets, and taking advantage of the methods of driving the sound reproducer diaphragm in the loud speaker that is available for the reproduction of sound in the loud speaker, as compared with that available in the talking machine

of 1910 to 1914 and the amount of energy or power, that is a thousand times greater; it may be in some instances 10,000 times greater; that does not mean that the amount of sound delivered is a thousand times as great or ten thousand times as great. It may be ten times greater or one hundred times greater, but the power available to operate the sound reproducing apparatus is perhaps a thousand or maybe ten thousand times greater than that that was available to operate a talking machine apparatus at the period referred to.

In both of the Hopkins patent, there is shown in the various drawings a direct mechanical connection for transmitting the vibrations from the stylus to the cone.

The dynamic speaker of the present day uses an electro-dynamic principle that was devised more than 100 years ago. It is a principle that a magnetic field may be produced by a current passing through a coil of wire so that a strong magnetic field is produced inside of this coil. In the construction that we have here in the Fada loud speaker attached to near to the apex of the cone, the frustrum of the cone, is another coil of wire which is arranged to be supported in the interior of the outer or field coil.

The field coil is energized, made magnetic, made strongly magnetic, by connecting it to the current supply of the electric lighting circuit. The variations of the current from the radio loud speaker from the coil attached to the paper causes the coil attached to the paper to move back and forth in the field of the field coils and by proper design making the field magnets powerful, they being supplied by separate electrical energy from the lighting circuit, and the design of the smaller movable coil attached to the paper is such that when it is in radio operation the force moving the vibratory part of the reproducer can be made very

powerful and a reproducer in which there is the field coil separately energized of the movable coil attached to the paper so that it can move in and out in response to the electro acoustical vibration is called a dynamic speaker and the amount of energy available to drive the vibrating diaphragm is very greatly increased in this manner and the Fada reproducer is of this dynamic type.

Referring to the structure of the Hopkins patent shown in the patent No. 1,271,527, for example, Fig. 4, the needle is in contact with the record.

In Fig. 2 the needle is out of contact with the record showing how a record can be removed.

In the position shown in Fig. 2 where the needle stylus is removed from contact with the record that the needle and the levers connecting the needle with the vertex of the cone are held in their normal positions by the cone itself, which further is supported at its edges. The structure shown in the patent which permits the movement of that assembly from one position to the other whereby it can hold its position where moved consists of the following:

There is perhaps first the massive rings which in Fig. 4 are lettered K,K′.

They are the rings that are called ponderous rings in the patent.

Those rings clamp between them the periphery of the cone L in such a way that it is supported in its normal position, but is subject to such vibratory movement as is desired in the reproduction of sound.

Attached to the vertex of the cone is a fixture, probably of metal marked M to which is attached a slender metal rod running upward in picture 4 until it joins another rod horizontally placed and connecting the vertical rod from the vertex of the cone to the needle which is pivoted on the other end of the tube marked G.

When the stylus moves, its vibratory movements are transmitted through the horizontal rod at the joint there which is shown in another figure in more detail, in Fig. 6, in such a way that the horizontal movements from the needle, horizontal as we look at the pictures, horizontal movements from the needle transmitted by the rod S′ to the joint at S and then through a pivot and connecting parts to the vertical rod V, which in turn connects to the vertex of the cone. These various parts are maintained in their normal operating position through the cone which as I have said is itself in turn supported in the ponderous rings K,K′.

If the structure did not have the rings K,K′ it would dangle freely in the air and these parts would fall out of their normal position when not in use and if there were no heavy ring around the periphery of the cone it would not operate to reproduce sound at all even when the needle vibrated in the record and even if the parts were properly suspended.

It is necessary to establish inertia or unmovable parts around the edge of the cone in order that the rest may vibrate back and forth. The inertia of the periphery of the diaphragm is a necessary feature in all talking machines and photograph reproducers in sound boxes and it is here. That is provided in this case by these heavy rings.

Not only are these rings essential in the Hopkins structure, but it is necessary that they should have a substantial amount of mass for the proper operation of the machine.

As to what parts shown in the patent move as a unit when the needle is moved on or off of the record, taking Fig. 4 for example, I would say the whole framework, the supporting rings K,K′ and the parts J that support them, the vertical tube marked G and the horizontal tube G, which support within themselves the

lighter levers. The whole must tilt in the manner shown in Fig. 2.

There is a Gimbel mounting provided and so described so that this can lift off the whole part of this reproducing apparatus including the sound reproducing diaphragm and its supporting frame can be lifted bodily without displacing parts relatively one to the other.

Q. 47. Now, let us come back again to Patent No. 1,271,527, page 2, line 128. The Hopkins patent states:

> "A tympanum L of light vibratile material has an annular plane peripheral portion *l*, the outer edge of which peripheral portion or supporting rim *l* is tightly gripped and rigidly supported between the ponderous rings K,K′ and a central conical portion *l′* rising from the inner edge of the annular plane peripheral portion."

There seems to be some dispute as to what is meant by tympanum. I will read you a definition of this term which was advanced to the Patent Office on February 5, 1915, as appears in the file wrapper of this patent we are considering.

> "We respectfully solicit a careful consideration of the new claims 11 to 16 inclusive, which have been redrawn following somewhat the form of Claims 1 and 2 to define a tympanum of such area as to produce directly regenerated sound waves substantially corresponding in intensity or amplitude to the recorded sound waves."

Do you agree with that definition of tympanum as employed in the patent?

Mr. Davis: I object to that question as irrelevant on the ground that whatever may have been said in argument to the Patent Office is irrelevant

to the present discussion. The law in this circuit and of the other circuits, as I said the other day, is to that effect, I think, without exception.

MR. DARBY: I think I will point out some exceptions to Mr. Davis and I do not think that that is the law. I agree with Mr. Davis that a great many decisions on the proposition of the value of a patent file wrapper for use against the patent is limited to estoppel, but I do not agree with Mr. Davis as to what constitutes the estoppel. I have got authority for it specifically in this particular case by the two decisions outstanding now of Judge Bourquin and Judge Hickenlooper right squarely on this case. I think there are plenty other authorities that on the question of estoppel you can use any part of the prosecution.

THE COURT: What have you to say to those two opinions?

MR. DAVIS: I say they were wrong. They were contrary to the decisions of their own Courts of Appeals, and perhaps your Honor is not so particularly interested in that as in the decision of this Court of Appeals. I have a memorandum at the hotel on the subject. There was a case in our circuit just the other day, within the last two or three months, in which Judge Hand, after saying that the Court of Appeals had said half a dozen times that it would not consider the discussions between the solicitor in the Patent Office, said, "We say now once again and finally that we will not under any circumstances consider those discussions," citing a lot of cases, and I ought to be able to remember the case in this circuit, but it slipped my mind for the moment.

THE COURT: I am not sure, but I rather think that I sat in the Circuit Court of Appeals, and I am not sure whether I sat in the case or simply remember it. My recollection is, and I am not certain about it, about the limitation upon that point, but I think that my recollection is that the law in this circuit as laid down by the Court of Appeals is as Mr. Davis states it. However, rather than to foreclose you by sustaining the objection in making such contention with regard to the law as you may deem proper, I will let you take the answer, but I think the burden with respect to the law will be upon you, Mr. Darby.

MR. DARBY: I will accept the burden.

THE COURT: You may have an exception to save all your rights. If the law is as you suggest, Mr. Davis, the taking of the facts will not make any difference.

MR. DARBY: I might say this, that I was looking for a concise definition of the word tympanum and this language was very concise and clear and it comes to me as a surprise that Mr. Davis questions it.

THE COURT: As I understand it, you find that definition satisfactory to your purpose and you are incorporating it here by reference regardless of whether it has any effect by way of estoppel or not.

MR. DARBY: Yes, sir, that is the purpose.

(Last question repeated as recorded.)

A. This is not a definition of the term. It is a description of what the tympanum of the patent is presumed to do. It is a sound-reproducing area which does reproduce sound.

THE WITNESS: Referring again to this paragraph that we are discussing and particularly the first few words: "A tympanum L of light vibratile material," refer to Fig. 3 of the patent. The tympanum consists of the conical portion *l'* together with the flat annular portion or peripheral portion *l*, which in effect is continuous with the cone, the tympanum therefore consisting of the light vibratile material forming all of the material which is inside of the clamping rings K, K'. Every part of it is of light vibratile material as described and shown. Every part of it is capable of vibrating and producing sound.

Referring to the Fada loud speaker, the tympanum is that vibratory part which is effective in reproducing sound waves. In the Fada structure it consists of the conical portion with the vertex of the cone cut off where the coil wire is attached, so that it is the frustrum of the cone and as an affective tympanum it ends at the edge of the cone.

The vibratile material ends at the edge of the cone. The cloth rim which connects the edge of the cone with the baffle rim is not vibratile material in the sense in which I understand that word to be used for the purpose of giving out sound waves.

As compared with a vibratile material to give out sound, the cloth is a pliable material. In contrast to what has been referred to as vibratile material, it is not a vibratile material, but a pliable material. It is a porous material and being pliable and porous it is not a suitable material for generating sound waves in the air as are required for the production of sound.

The fact that it is not so suitable is taken advantage of in the construction of many musical instruments; in pianos felt is used in many places to dampen out the sound and absorb them. In the treatment of auditoriums for acoustic purposes where it is desired to absorb the sound, it is found that a porous pliable

material will absorb the sound and does not reproduce them.

Going back to the same passage that we are reading from, it is stated, line 130, page 2: "The outer edge of which"—referring to the tympanum or the annular plane peripheral portion of the tympanum—"The outer edge of which peripheral portion or supporting rim *l* is tightly gripped and rigidly supported between the ponderous rings K,K'."

The tympanum of the Fada structure is not tightly gripped between any ponderous rings, in my opinion. The tympanum of the Fada structure is not provided with any supporting rim of the same material as that of the tympanum. It is not provided with any supporting rim of vibratile material capable of giving off sound.

Referring to Plaintiff's Exhibit 5, the diameter of the tympanum, as I interpret it, is that marked in the drawing Fig. 2 by the dimension lines *b* and I have no rule here to measure it, but if I take them from the figures which are on the drawing for the small speaker the diameter of the tympanum is seven inches and for the large speaker 8½ inches.

The patent states, page 3, line 5:

> "If satisfactory regeneration of sounds from a record is to be had, the whole diameter of the tympanum, that is, the diameter of the aperture in the rings K,K' should exceed nine inches in order that the conditions shall be fulfilled which are required to regenerate the sound waves in the manner above described."

I have this to say as to the question of size of a vibratile tympanum, at least as to any minimum size of a vibratile tympanum in the acoustical art:

In order to regenerate the sound waves it is necessary that the waves of compression and refraction in

the air be reproduced or regenerated in such a manner as to contain an amount of energy which when transmitted by the waves to the tympanum of the ear will give the sensation of a sound substantially equivalent to the original source of the sound.

It is the amount of energy which is received by the ear which determines whether the sound thus received is a proper reproduction or regeneration of the original. This amount of energy can be secured from different areas of vibrating diaphragms or tympanum in the reproducing apparatus.

If the amplitude or the actual power per unit area is small, the diaphragm may have to be large in area and move through a small distance in order to reproduce this sound. In another case, if the diaphragm of the reproducer can be made to vibrate through a much larger amplitude, it may be very much reduced in size and yet generate waves of sufficient intensity to reproduce the sound as heard by the ear in its original intensity, and there is no fixed definite size of diaphragm that is required for the purpose of reproducing sound.

There is for any given conditions an adjustment between the power of the reproducer and the mass inertia of the moving diaphragm and its area and its freedom movement and so forth, an adjustment between these various parts, so that an adequate reproduction can be secured, but there is no essential diameter which is required for this purpose. A small diaphragm may reproduce loudly under proper conditions, as loud or louder than a large diaphragm, and in many cases with equal perfection of reproduction.

If any such theory, as that size alone is a controlling and determining factor, is or has been advanced, I would disagree with that theory.

The device I now produce consists of a paper cone about two and a half inches in diameter, the simple cone, attached to a magnetic unit and its outer edge is

connected with the frame by means of a soft leather or chamois skin periphery ring which serves as a baffle. It is in fact simply a small cone of paper not over two and a half inches in diameter mounted in the form of a loud speaker and this will reproduce a sound.

(At this point a demonstration was performed.)

MR. DARBY: I offer in evidence the two and a half inch cone loud speaker.

THE COURT: It is admitted without objection.

(Received in evidence and marked "Defendant's Exhibit No. 8.")

THE WITNESS: This two and a half inch loud speaker is provided with a magnetic drive. It is attached to the armature of a magnetic unit. The magnet is another type of driving unit for radio loud speakers in which the diaphragm is moved by means of an armature attached to it by light driving rods, the armature playing between the poles of a magnet.

MR. DAVIS: If you just say as distinguished from the dynamic type which I have already described.

THE WITNESS: As distinguished from the dynamic type which I have previously described.

The magnetic type in general is a smaller type and in general somewhat less powerful.

This two and a half inch cone has been set up in the form of an ordinary radio loud speaker.

I have had the specifications of the Brandes loud speaker but have not had it in my laboratory. I have examined the Brandes form of loud speaker which Mr. Davis has put in evidence as Plaintiff's Exhibit C for Identification as illustrating the cone structure

which was before the Court of Appeals in the Brandes case, and on the question as to whether or not the rubber ring interposed between the cone and the supporting ring is of vibratile material, I have this to say—The rubber is a non-porous material in the sense in which we use the word porous. It differs distinctly from the cloth in that if it is vibrated it would transmit its vibrations to the air. As mounted in this apparatus the rubber rim is very slack and its frequency of vibration will be so low that it will not attribute essentially to the acoustical output. The material, however, would be a vibratile material of varying frequencies, depending on the tension under which it happens to be placed and in that sense it is more vibratile than the other.

If the slackness were taken up by a tension its power to transmit sound to the surrounding air would be increased.

In the Brandes structure the surrounding ring does not support the cone through the medium of the rim.

The cone is supported from its apex by an attachment to the driving unit.

The rubber here in this thing here is substantially non-porous. And in that respect it is different from the cloth rim of the defendant's structure. In making the cloth ring of the defendant's structure a dampener or softener as compared with the vibrator or sound producer, its porosity is an important factor, a principal factor.

The character of the material and the character of the cloth play a part.

Returning once more to the patent, page 3, line 39 of Patent 1,271,527, this statement appears:

> "The conical shape is given the tympanum so that shocks or vibrations impressed upon the apex of the cone in a direction towards its base will move the whole cone bodily, the strains being imparted edgewise of the material and no wave mo-

tions being set up in the thin material of the cone. The curvature of the walls of the cone preclude the setting up of waves in the material and the intended object, a simultaneous movement of the whole conical portion of the tympanum, is attained."

I do not believe that language needs any explanation.

I understand what is intended to be meant by it. In normal use in radio reception the Fada cone does have waves set up in the body of the cone itself with the formation of nodes and loops.

I have examined many patterns made of Fada cones illustrating that.

Q. 85. I would like to have you demonstrate a slightly larger cone and please describe that cone structure.

THE COURT: In the last exhibit was the diameter given, the entire opening of the wood or was it the cone?

Q. 86. The entire opening of the wood?
A. No.
Q. 87. What was the diameter that you gave?
A. The diameter of the paper cone itself.

By THE COURT:

Q. 88. Not of the opening of the wood?
A. No.
Q. 89. Which contained a band around the wood?
A. Ring of leather around it.

By MR. DARBY:

Q. 90. That was just the cone itself?
A. Yes.
Q. 91. Did you include the leather?
A. I did not, but just the paper cone.

MR. DARBY: The entire diameter of the paper cone plus the leather ring is 3⅛ inches in Exhibit 8.

THE COURT: And the cone itself was what was given by the witness.

MR. DARBY: Yes.

By MR. DARBY:

Q. 92. Will you give us both of these measures in this structure, please?

A. The paper cone in this case is about 3½ inches and the opening in the front board is 4 1/16 inches. It is bevelled inside and is slightly larger where the leather touches it, about 4⅜.

(At this point a demonstration was performed.)

THE WITNESS: On page 3 of the Hopkins patent, line 24, appears the following statement:

> "The plane peripheral portion *l* of the tympanum maintains the place of the conical active portion of the tympanum and yields sufficiently to permit of the required motion of the conical portion, resisting, however, displacement of the conical portion in just that degree necessary to maintain the form and neutral position of the active conical portion."

The Fada cone is supported in its natural position and restrained just in the degree required for its movement in the production of sound by means of a spring arrangement consisting of three arms attached at one end to the vertex of the cone, the frustrum, and at the other end to rigid supports connected with the main base or frame, and it is the tension of this spring that maintains the cone in its neutral position.

The rim of cloth around the edge does not contribute to the maintenance of the cone in its neutral position, they lying in a flat plane and under the ordinary condition of construction they do not exert any force on the front and back, so that it is maintained by these three springs attached, and it would be so supported and in operable condition with the cloth rim entirely removed.

When the cone is forced forwardly or rearwardly in accordance with its movement, a very slight tension will be exerted on the ring, but in its neutral position it is not supported.

In the Hopkins patent this statement is made:

> "The peripheral portion *l*, the plane peripheral portion *l* of the tympanum maintains the conical active portion of the tympanum and holds sufficient to permit this required portion, the conical portion in just that degree necessary to maintain the form and neutral position of the active conical portion."

That description from the patent describing the Hopkins structure, does not fit the Fada structure.

The function of holding the Hopkins cone in this neutral position, which function is performed as stated by the patent, by the plane peripheral portion of tympanum is essential in my opinion to the successful operation of the Hopkins device.

THE COURT: Are you answering that mechanically, speaking from a mechanical standpoint?

THE WITNESS: I am speaking of the technicality of the patent.

THE COURT: All right.

Mechanically speaking, the cloth rim of the defendant's structure does not perform that function.

As I interpret it, the cloth rim in the Fada device serves to hold the paper cone against the force of gravity from such sagging as might take place on account of the flexibility of the central springs. It also prevents a certain amount of the weaving or fluttering at the edge, but does not exclude the formation of segments in the body of the material. Its chief function is probably to close the air gap between the edge of the cone or tympanum, and the ring around it of the housing, to form in connection with the casing what is commonly referred to now as a baffle. It prevents the leaking of the sound waves which consist of compressions and rarefactions and prevents the leaking of these around under the back of the cone or diaphragm, and thus increases the acoustic efficiency of the apparatus, and also improves tone quality. This baffling effect is an old principle but it is being made more prominent in every day use by the much larger power that is being applied to reproducers at the present time.

MR. DARBY: My attention has been called to the fact that I failed to offer in evidence the second cone of the small type, which we demonstrated and I now offer it in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 9.")

With reference to the testimony that I have given with respect to what effect size has on a reproducing diaphragm in acoustics, the statement which I intended to make was to the effect that there is no critical size which is essential to a proper reproduction of sound. A proper reproduction I understand means that when a person is speaking, the sound is received by a microphone, for instance, and it then goes from the broadcasting apparatus, is transmitted by radio, and is picked up by radio receiving apparatus, and is

reproduced at some distant point, by the loud speaker, and an adequate reproduction is one in which the person listening to the loud speaker far away, shall hear in its essential acoustic quality and characteristics, the orginal song, which may be speech, or music, or something else. The most critical conditions are involved in speech and in musical reproduction.

It is quite certain that if we hear an adequate reproduction, a satisfactory reproduction, that the sound waves which come from the loud speaker to the ear at the receiving station, must correspond as closely as is required to satisfy our judgment in the matter—must correspond to the sound waves originated at the source by the original speaker or the original music, and they are both of them acoustic waves; they are waves in air at the source and equivalent waves to the degree in which we are satisfied, and in modern reproduction we get beautiful effects under good conditions.

So that the waves reproduced in that receiving station are acoustically equivalent to the waves in the first station. The waves in the first station must go into the microphone, acoustically speaking, the waves must be impressed upon that. That microphone then must vibrate in an acoustical sense in such a way that its vibrations contain the essential characteristics of the orginal sound waves; and that microphone, as now used, in the best service, is about three inches in diameter, sometimes less, I do not know of them as being any larger. I have seen some very recent ones, and the best ones, so that a three-inch diaphragm in a transmitting microphone, the pick-up microphone must vibrate with the essential characteristics, acoustically speaking, that represent the original sound waves, and those are transmitted by whatever process we like, to the distant station and the electro-magnetic disturbances are reproduced in the loud speaker, and come out of this diaphragm.

Now, if the three-inch diaphraghm of the microphone transmitter can vibrate acoustically in accordance with those waves, there is no essential acoustic reason or mechanical reason, why a three-inch diaphragm at the receiving station, should not also be made to vibrate in equally perfect acoustic respects, so as to reproduce a corresponding regenerated sound wave at the distant station; and furthermore, telephone diaphragms are all of them less than three inches, so far as I know, and we get acoustic effects from air waves, strictly acoustic, into the transmitter of the telephone, into the small diaphragm; and the fact we put it to our ear does not change the characteristic waves of that sound. We can hold it away from our ear. Loudness is no matter, but we reproduce the true characteristics of those sound waves from the telephone receiver, which uses a diaphragm that is not large, and still another illustration is a phonograph in the talking machine, where the records are made with a recording device which has a small diaphragm which might contain acoustic vibrations, corresponding to the original sound wave. So the argument is that the mere size of the diaphragm does not preclude proper vibrations of the kind to correspond to the original spoken sound or musical sound; that is, the size can be adjusted to other factors so as to obtain correct reproduction.

The satisfactory loud speakers of the present time so far as I know all have a baffle, either in extended plane surface extending out some distance two inches or a foot or more on each side, or the speaker is inserted. This part of the speaker, the chassis as it is called, is inserted in a casing or housing or cabinet and closed up with it in some such a way as the housing or cabinet forms a baffling, such a baffling of sound waves is theoretically in the study of acoustics a very old requirement.

The Fada loud speaker is not intended to be used in the open air, and I will say is never used in that fashion, as a completed instrument. They might use it in a laboratory for pure experimentation for any given purpose; if we wish to hear adequate reproduction and reproduction in the laboratory, we must apply a baffle, and this outer felt ring is intended to be pushed up against the housing or casing in that way, forming a baffle. This can be illustrated by the Fada instrument which is here, by the way. The effect of baffling can be shown by sounding it outside. Is it to be demonstrated?

I recognize the cabinet produced as a standard Fada cabinet. I will describe it.

There is this opening in front through a grill work here, but which is in effect a circular opening in the interior. The grill work is merely ornamental on the outside. It has a circular opening of such a size that when the unit is inserted, the felt ring, the thin flat felt ring on the outside of this mounting comes up against the front of the box in such a way as to make a moderately air-tight closing and produces a baffle, the sides of the cabinet completing the baffle. There is also a certain amount of resonance effect produced by this cabinet, but the baffling is the first and most essential part; and the removable rear part of the cabinet, is perforated in such a way that it allows sound to come from the rear. It has a very slight acoustic effect undoubtedly, but hardly noticeable.

There is no opening to the atmosphere in the top, bottom, or sides, other than the front and rear which I have mentioned.

MR. DARBY: Will you please work the Fada without the cabinet. (Demonstration of music.)

I will describe the effect the cabinet had on the quality of the sound.

The cabinet acting as a baffle, and as a resonator improves the general distribution of the tone intensity over the different pitches, so that with the cabinet attached, the lower frequencies which form the foundation of the musical tones, the lower frequencies are more prominent, forming a better balance throughout. The general effect is an improvement, that is also upon the whole been rather louder with the cabinet, because the sound waves are not dissipated by leaking around the back and the interference effects.

MR. DARBY: I offer in evidence the standard Fada cabinet for use with the Fada small type of speaker in suit. At Mr. Davis's suggestion I offer in evidence the small Fada unit employed with the last demonstration.

THE COURT: The small unit comes in as Exhibit No. 10 and the cabinet as 10-A.

(The unit was received in evidence and marked "Defendant's Exhibit No. 10." The cabinet was received in evidence and marked "Defendant's Exhibit No. 10-A.")

Referring to the dimensions of the two Fada structures, in the larger cone, the altitude is equal to one-half of the base, that is 50 per cent. and in the smaller cone, the altitude is just over two-fifths of the diameter of the base of the cone, expressed in per cent., 41 per cent.

THE COURT: Is that to the apex?

THE WITNESS: That is to the apex, if it were carried out to a complete cone, that is the measurement from the plane of the base to the apex of the cone.

Q. 112. And the altitude of the cone is always measured to its apex, is it not?

A. If you speak of the cone, yes, that is correct.

MR. DARBY: I offer in evidence a folder of prior art patents and publications consisting of—does your Honor care to have me read on the record the patents included in the folder? They are all bound together.

(The folder of prior art patents and publications was received in evidence and marked respectively "Defendant's Exhibits 11 to 11-L" inclusive.)

THE WITNESS: Briefly describing the structure illustrated by these patents—the first patent that I call attention to is by Maxwell, No. 216,051, dated June 3, 1879. This patent describes the formation of a cone or reproducing sound, the cone being formed of paper or other material. It says, on page 1, two-thirds of the way down, in column 1, the lines are not numbered—

> "The sounding boards may be made of soft pine wood or any other suitable material and have openings in their central portions over which the vibrators are to be fastened, and should be mounted upon suitable supports all enclosed in suitable boxes, and should be made quite thin in order to increase their capacity for vibration."

This is referring to the surrounding box or casing similar to what I have recently referred to as the baffle.

> "The vibrators are made of sheep skin or like material and should be fastened upon the sounding boards over the openings therein, while in a wet and plastic condition, and then have their central portions drawn out and stretched until they assume a funnel-like formation, and then be allowed to dry and retain that form."

The patent states in the last column of the second page:

> "I have found also by experiment that a vibrator that is from 7 to 8 inches in diameter through the center from one outer edge to the other is the most efficient, and when they are left smaller than this, the vibration made by the vocal organs are of a nasal character, but in each apparatus provided it is used at one end of the line——"
> Here referring to a telephone transmission—
> "a very much smaller one may be used at the other without impairing perceptibly the effect."

Q. 114. This describes the formation of the sound reproducing diaphragm from a thin material put into a conical form by stretching and drying, and we have such a cone made in accordance with the dimensions and descriptions of this patent, which is to be demonstrated.

MR. DARBY: I will operate this cone referred to by the witness. (Demonstration.)

THE COURT: Won't you tell me about that, Mr. Darby? The sound portion, is that facing the clock, is it not, that is the vibratory portion?

MR. DARBY: It is built exactly in accordance with the patent.

THE WITNESS: The patent describes the double cones and also a single one.

THE COURT: That is like figure 1?

THE WITNESS: Yes, sir.

MR. DARBY: Yes, mounted of course with radio loud speaker equipment.

THE WITNESS: This patent as I understand it, was thought of at that time as constituting a telephone

transmitter and receiver, consisting of two cones, one at one end, one on the other, which would be represented in this model; one of the cones alone would be used as a transmitter or as a receiver and a single cone built according to the same specifications is in the other box.

MR. DARBY: I offer the model of the Maxwell patent with radio loud speaker in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 12.")

Q. 116. Will you describe the second structure?

A. The second structure is made in accordance with the teachings of this patent of Maxwell, consisting of a single cone of bladder attached to the round opening in what he calls the sounding board, and is then stretched, and in this case, it has been covered with this varnish which stiffens it a little without much adding to its weight, to show that a cone of this kind of material will give a good tone quality.

MR. DARBY: I offer this last second model of the Maxwell structure in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 12-A.")

THE WITNESS: The next patent to be referred to is that of Damm & Lapp, No. 338,660, dated March 23, 1886. I wish to call attention to such features as seem to apply to the arguments under consideration. He says on the first page, line 14:

"The object we aim at and have attained is the production of a loud speaking instrument capable of operating with a minimum expenditure of battery power or electro-motive force."

This was in connection with a telephone transmitter. In line 33 he says:

"The sheet metal diaphragm A is constructed with a central conical portion A which may be formed integral therewith or made separately and attached by soldering, brazing or any other suitable manner. The diameter of the base of the hollow cone may vary considerably"—and so forth.

On page 2, line 44:

"A still further advantage attends the use of the cone since it is capable of withstanding the pressure and thrust to which it is subject in connecting on the attached lever, and hence the diaphragm is made correspondingly more durable than if constructed in the usual form."

Now, in line 60:

"Our improved diaphragm is applicable to other telephonic instruments besides transmitters."

Next, at line 80, page 2:

"It is also expedient to employ dampers or elastic pressure plates as shown in the drawings, to limit the vibrations of the diaphragms and choke out the metallic clamp-using the dampers or baffles for one of the purposes which we have been describing in our testimony."

With respect to the dampening that I have read from in connection with this patent, damping of the kind here described would, in a considerable degree, lessen the fluttering of the edge of the cone and increase and produce a desirable effect.

It is possible to effect dampening in varying degrees in proportions by attaching a paper or soft leather or rubber ring around the edge of the cone and attaching this ring to the framework, to attach a piece

of soft felt to the casing and then push the free edge of the cone into slight contact with such a felt ring. It is possible to secure a certain amount of damping in the sense of preventing the fluttering by simply pasting a piece of felt on the cone itself around the edge of the cone, and thus improve the quantity of the tone which will be obtained from the cone.

These two diaphragms of different sizes are made in accordance with the description and the drawings shown in the patent consisting of the conical portion and the flat periphery rim.

MR. DARBY: I offer the two structures in evidence, coupled with the statement that the patent says nothing about it.

(Received in evidence and marked "Defendant's Exhibits Nos. 13 and 13-A," respectively.)

THE WITNESS: Considering the Stroh Patent No. 3393, this patent describes a diaphragm for use on phonographs and musical instruments and other sound-producing and recording and transmitting apparatus which consists of a conical central portion in metal or other suitable material and has a surrounding periphery portion which is described as being made in three different forms.

One is a flat peripheral portion shown in Fig. 3 and another is largely flat but has one or one and a half corrugations, and in Fig. 1 it is shown with several corrugations, the purpose of the corrugations in addition to their effect produced by the ordinary flat portion is to permit the central conical portion to move back and forth in the direction of sound.

This instrument is again a diaphragm of moderate size and has been used for musical purposes in connection with the Stroh violin, which has actually been used in making phonograph records, commercial records for

sale, and is a diaphragm of moderate size made in this form.

I have seen a Stroh violin. I have heard it in actual use. I have seen it in use by artists performing upon it. I have heard it in the laboratory many times. It is an instrument such as is here before us. It has this diaphragm to which is attached a horn. Its usefulness in connection with recording is that it will direct the sound of the violin more directly into the recording apparatus which is found advantageous in that case.

The point of argument that I wish to make from the introduction of this idea is that this diaphragm with the central conical portion of this rim, which in the patent is described as perhaps being flat or conical, either one, to permit this, and the argument to be made from this is that this instrument has actually been used for the reproduction of first-class musical records which have been commercially sold. This instrument was so used until recent times.

I have said that the horn was directed more into the recording apparatus and it has been found more effective than trying to get a violin alone. In the recent recording devices, the electric recordings, as they are called, it is found satisfactory to use the violin direct.

MR. DARBY: And I might tell your Honor that this identical instrument has been used by the Victor Company in its recording since 1904.

THE COURT: Does Mr. Davis concede that?

MR. DARBY: Yes, sir, it is stipulated. Your Honor will get an idea of how it works.

(At this point Mr. Darby played a tune on the Stroh violin.)

MR. DARBY: I will ask to have the Stroh violin marked for identification inasmuch as it will be

offered in evidence in connection with some stipulated testimony.

(The same was marked "Defendant's Exhibit C, for Identification.")

THE WITNESS: These three diaphragms I produce are made in strict accordance with the three different figures of the Stroh patent.

MR. DARBY: I offer in evidence the three diaphragms corresponding to Figs. 1, 2 and 3 of the Stroh patent.

(Received in evidence and marked "Defendant's Exhibits Nos. 14, 14-A and 14-B," respectively.)

THE WITNESS: Taking up the publication of Starling & Cole, the structure shown is a conical reproducer eight inches in diameter, about, and two and a half inches in height, preferably made of paper.

Those figures are given in the article, the diameter about the middle of the first column of page 1 and near the end of the article in the second page is that it may be set up in cardboard but that paper is the material that has been found most suitable. Such a cone as this eight inches in diameter is here shown as a talking machine reproducer acting in the open air, the edge of the cone being entirely free.

I have examined the paper cone I now produce and it is made in accordance with the description here given.

MR. DARBY: I offer in evidence the cone made in accordance with the Starling & Cole article.

(Received in evidence and marked "Defendant's Exhibit No. 15.")

THE WITNESS: I have examined the two cones that I have in my hand and determined that they are made in accordance with the Starling & Cole article except that they are provided with attachment means at the vertex of the apex of the cone instead of a needle means.

MR. DARBY: I will ask that this be connected to a radio loud speaker equipment.

(At this point a demonstration was performed.)

MR. DARBY: This is demonstrated now with a baffle over it. (At this point a further demonstration was conducted.)

Now I would like to demonstrate what increasing the laboratory power on the instrument, what effect it has on the cone. (At this point a further demonstration was conducted.)

Increase the power. (At this point a further demonstration was conducted.)

THE WITNESS: With the increased power the edges of the cone are fluttering, weaving it is sometimes called, and that introduces a disagreeable paper rattling sound in a cone of this structure.

That is sometimes referred to as blasting. It is weaving. Blasting is an excessive power that destroys the proper tone quality and that is one method of producing it, by weaving or fluttering of the edge.

THE WITNESS: The cone which I now have in my hand is of the same construction exactly, except that this has a rim of felt cloth around the edge of about three-eighths of an inch wide.

By THE COURT:

Q. 138. Around the inner edge?

A. The outer edge on the inside of the cone, and that reduces the amount of this blasting or fluttering

effect as can be shown by starting this in operation and changing the cones without changing the adjustment.

(At this point a further demonstration was conducted.)

MR. DARBY: I offer in evidence the Starling & Cole cone provided with a chuck to permit attachments to the vibrating pole of the radio loud speaker.

(Received in evidence and marked "Defendant's Exhibit No. 15-A.")

MR. DARBY: I offer in evidence the Starling & Cole cone provided with the felt damper at its peripheral edge.

(Received in evidence and marked "Defendant's Exhibit No. 15-B.")

MR. DAVIS: I am not at all sure that the record is going to tell us whether the demonstration matches up with the two cones, and if it does not may it be agreed that Mr. Darby and I will fix it up.

THE COURT: I thought probably you would ask the witness whether his prophecy was carried out.

MR. DARBY: I will do that.

By MR. DARBY:

Q. 139. Will you please briefly state what effect in actual operation was observed when you, with the same power, used the cone with the felt damper?

A. The quality of the sound was appreciably improved when the cone with the felt strip around the edge was used, due to a lessening of the higher frequency sounds and a relative enhancement of the sounds of lower frequency, giving a better balanced musical reproduction.

Now, referring to the Kraemer Patent No. 890,142, this patent was referred to in the prosecution of the Hopkins patent and it seems to me that it merely shows a truncated cone with a flat peripheral portion. I do not know that there are any peculiarities that need to be emphasized.

Now, referring to the Lumiere Patent No. 986,477, I call attention to the statement on page 1 of the paragraph beginning at line 67, which refers to bringing the surfaces of a vibrating body into a condition of molecular stress by torsion.

I understand by that expression in the construction here shown in the patent the paper is taken and so folded and formed that it is twisted in such a fashion as this, so that there is a torsion produced in this sheet of paper which puts the paper somewhat under tension and makes the surface a curved one, thus increasing its rigidity. It is a more rigid piece of paper without increasing the weight.

A piece of paper bent in the form of a cone is under the stress of torsion.

The cone is not put into the stress of torsion, but it is put into a curved form in such a way that it can transmit stresses much better than it is in the flat condition.

In the same paragraph of the patent, on page 1, the reference is made to the disagreeable effect which is technically known as blasting or chattering. That is the effect to which we have referred previously, and the patentee states that he wishes to obviate that by stiffening the material without increasing the weight which is accomplished by the method of folding and bending described.

I call attention to the passage in this Lumiere patent, beginning at line 29, page 3, down to and including line 46.

I think the description is correct, acoustically speaking.

I have used Lumiere machines experimentally on various occasions here and at home in my own laboratory.

I produce a Lumiere phonograph.

MR. DARBY: I will ask to have it marked for identification and I will tell your Honor that this is the original Lumiere machine that has been in this country and in the possession of the Victor Talking Machine Company since 1909 or 1910.

(The same was marked "Defendant's Exhibit D for Identification.")

THE WITNESS: In this Lumiere machine the cone is about 11⅝ inches in diameter inside of the clamping rings and appears to be made of thin paper.

The structure I now produce is a diaphragm made in accordance with the Lumiere patents which we have just been considering and it bears the trade-mark of the Victor Talking Machine Company.

The diameter of this cone is 14¼ inches inside of the clamping rings.

MR. DARBY: I ask to have this diaphragm, which is now mounted on a radio receiver equipment, operated.

(At this point a demonstration was conducted.)

MR. DARBY: I offer this Lumiere structure in evidence as being made in accordance with the Lumiere patent.

(Received in evidence and marked "Defendant's Exhibit No. 16.")

THE WITNESS: Referring to the English Patent No. 1,064,062, this structure consists of a conical vibrating diaphragm, supported in rings, there being a peripheral surrounding portion which in the patent is described as preferably made of soft flexible rubber.

Paper is mentioned as a suitable material for the conical portion.

It is described and illustrated to be used on a phonograph.

I call attention to a statement on page 3, line 19. The purpose described here is to make a flexible rim so that the central conical portion may move back and forth, the rim yielding as is necessary for this purpose. The peripheral rim surrounding the central cone is made of very light thin rubber so that the bending of the peripheral rim will not appreciably absorb the energy of the sound and so it will allow it to operate at maximum acoustical efficiency.

The cone itself is made of paper as pointed out at page 2, line 12.

Referring to English Patent No. 1,192,289, the patent describes the diaphragm consisting of a central conical portion and flat peripheral portion which is made of cork or other yielding material attaching the central conical portion to the supporting ring.

The Hopkins patent differs from English in that the flat peripheral ring is made of the same material and the cone is more rigid and serves somewhat as a part of the tympanum, whereas in this case the cork would produce very little effect on the tympanum.

The English is a small diaphragm of a size suitable for talking machine, as it was made in 1916. With reference to the statement of the English patent at page 3, line 11, as compared with the statement concerning which I testified made in the Hopkins patent as to its intended operation of bodily movement without flexing, the description in English patent of the mo-

tion is similar to that described by Hopkins in his patent. The central portion fibrates as a whole without flexing; that is the statement.

Referring to the Elfering Patent No. 1,182,078. This describes a diaphragm with the conical portion in the center and surrounding it is a peripheral ring of flexible material in which gold beater skin, a very thin membrane, is mentioned as a preferable material.

In respect to how this structure as shown differs from the corresponding parts in the Hopkins patent, the peripheral portion of Elfering is made of a very thin material which is more flexible than in the Hopkins patent, where the peripheral ring is made of the same material as the cone.

As to how the structure of the Elfering patent compares with the defendant's Fada cone structure, in Elfering the gold beater skin is a very thin material, but it is not porous and it has vibrations and these will be impressed upon the air, whereas in the Fada structure the cloth ring is a porous material.

As to in what respect this structure compares with the structure of the Brandes cone, the Brandes cone has a rubber ring surrounding it and in the specimen illustrated here the rubber is slack. In the patent it would appear that the gold beater skin is to be drawn taut. The nature of the surface of the material and its manner of affecting the air would be similar in the case of the two materials.

In the Brandes structure the rubber ring is of thinner material than the cone, and in this Elfering patent the gold beater skin is also thinner.

Referring to the Brown British Patent No. 29,833, the complete specification, this represents a conical central portion with a diaphragm placed in a mounting, the opening in which is slightly larger than the edge of the diaphragm, and here this ring between the dia-

phragm proper and the rings surrounding it, is covered with thin tissue paper. In its acoustic effect this will be very similar to the effect of the Elfering patent.

On the question of the desirability of clamping the periphery of the diaphragm, I call attention to the passage on page 3, line 41. In order that this may be accomplished, it states that the ring of flexible material such as paper is attached to it to allow this freedom of movement, and in a later place it says that by this method the back and front air spaces are separated. That is, the baffling effect is secured.

I call attention to the last sentence on page 3, reading as follows:

> "Where it is desired to make the sounds travel out into the room, a receiver of larger size is preferable."

That expression means to me as one skilled in the art, that the diaphragm is described as intended for telephone use, where it is placed close to the ear, and if he wants to make a telephone reproducer that can be heard without being placed near the ear, he states the obvious fact that it should be made larger, larger than here described.

I call attention to the sentence on page 4, line 34, reading as follows:

> "In either case the space on the two sides of the diaphragm is divided into two separate air regions."

That refers to the baffling effect which we have previously described, which prevents the leakage of air from front to back of the diaphragm and increases the efficiency in the reproduction of sound.

The Brown structure differs from the Hopkins patent in the fact that the periphery of the diaphragm is connected to the outer ring by means of a strip of thin

paper instead of the material similar to that to which the cone is made, as in the Hopkins patent.

Referring to the second Brown Patent No. 1157 of 1911, this structure is the same in general character. It consists of a conical central portion which is connected around the periphery, across the rim, separating it from the clamping rings by a flexible mounting of a folding character. It says slacked material such as goldbeaters' skin, so that the diaphragm will have freedom of movement as a whole. This is another instance of the differing but little from those we have just been mentioning.

I call attention to the statement appearing on page 4, line 26, as follows:

> "The width of the annular space must either be so small that the two air regions which are two sides of the diaphragm, may be considered as without communication with one another, or the ring of material must be used. In the latter case, the ring should be slack enough to permit of the diaphragm's movement without any appreciable mechanical constraint being put upon it."

I understand that refers to the effect which is described as baffling and leaking of the sound waves around the edge should be prevented by filling the space at the edge of the cone, being filled with this flexible material, so that the cone itself will not be constrained in its vibratory movements and yet so that the baffling effect will be secured.

This construction of Brown differs from the Hopkins patent in that the connection to the clamping rings is by means of this peripheral ring of thin material here mentioned as goldbeaters' skin, and further that in this case, the goldbeaters' skin is less slack or the mounting is of a folding character, so that there is material enough to give great freedom of movement, at the

periphery, instead of being rigidly clamped at the periphery as in the Hopkins patent.

THE WITNESS: I recognize this structure I now produce as the Pathé speaker.

MR. DARBY: I would like to illustrate the Pathé loud speaker. (Demonstration.) Now, I would like to compare that, for example, with Lumiere. (Demonstrating.)

I will offer in evidence the Pathé loud speaker.

(Received in evidence and marked "Defendant's Exhibit No. 20.")

THE WITNESS: As to the differences in operation of the speakers, speaking first of the Pathé cone, Defendant's Exhibit No. 20, I think that has the poorest tone quality of all those that we exhibited, although it is a commercial product, I understand, put out under this patent. The reasons for that are probably numerous. The reasons for the differences are numerous in all of them. Part of it is due to the material of which the cone is made. I think a considerable part of the difference that we heard is due to the unit that drives the cone in this case, but I think probably the cone itself does contribute in some degree. The instrument that seemed to me next best in quality, or that I should put next best, and next to that one that was the poorest—the poorest was the Pathé—it was thin and shrill in quality, which I think is due in part to the material and somewhat to the driving unit.

THE COURT: Will you give me the exhibit number? Because when I take this up I may have forgotten the numbers.

MR. DARBY: No. 20.

THE WITNESS: Exhibit No. 20.

THE COURT:

Q. 191. Which ones do you like the best?

A. The one that I like the best is this small 3-inch cone, Defendant's Exhibit No. 9; and I think that is due to the manner in which the cone is constructed, and to the soft, flexible material around the edge, which secures adequate baffling, and also prevents the formation of the rattling around the edges. I gather from these demonstrations that a small cone operated in a perfectly designed outfit, can give us results that are more satisfactory than a larger one, but it is not a matter of size only; it is a matter of design of the whole combination, including the driving unit and the baffle board materials, and other things.

THE WITNESS: Referring to the last patent in this prior art folder, the Lodge patent, this patent describes a dynamic motor for driving a diaphragm in a sound reproducer, but that is more or less general. It is one of the earliest ones of that type. It is desired to make a telephone which will give a sound loud enough to be heard without holding the telephone to the ear. It is perhaps the earliest loud-speaking telephone, and the inventor, Lodge, suggests that the driving mechanism may be attached to the walls of the room or to the ceiling in such a way that the sound will come from the walls or ceiling and be heard by the audience throughout in that manner.

On the question of sound-reproducing devices as distinguished from paper cones, that is, the ability of any material to respond to sound, it can be very easily illustrated with the driving units such as used in the radio loud-speakers.

Q. 195. Will you please do so, Dr. Miller?

MR. DARBY: Dr. Miller asked me to do the actual work on this and he will make his comments as we will go along. I might state to your Honor

that we have one of these standard motor drives without any cone or anything attached. This noise that you now hear is the armature noise by itself. There is no load on it.

(Demonstration.)

Q. 196. What is acting as the reproducer when I do it on the table?

A. The whole table top.

(Further demonstration.)

Q. 197. In that instance what was acting as the reproducer?

A. The sound-box and resonator in the guitar box itself.

Q. 198. Does it make any difference what the size and shape of the resonator may be?

A. It makes a difference, but with proper adjustments of the parts you can get good sound reproduction in various combinations, not merely a cone or a flat diaphragm, but combinations of anything.

Mr. Darby: I want to compare something else with that. (Demonstration with a derby.)

Q. 199. I think you testified that the cloth will not give off sound, but it is an absorber of sound. Will you see if you can get some music out of my handkerchief. First, put it in a crumpled-up state. (Demonstration with handkerchief.)

The Witness: I would like to demonstrate the change in the stiffness of the paper by using a piece of paper with one of these.

Q. 200. What have you to say as to the last demonstration with the handkerchief?

A. The handkerchief is porous and does not impress the vibrations on the air, and felt is more or less

of a solid material and is not porous. The demonstration that we can make with this sheet of blotting paper might be interesting as showing the method of taking a large area which is light in weight as paper as is done in these patents. (Demonstration with blotting paper.)

Q. 201. Now, Mr. Miller, what do those demonstrations which you have just made illustrate, including the one with the handkerchief or cloth?

A. Repeating the statements that I have made in a general way that sound vibrations in the air can be reproduced from elastic solid materials which can be set in vibration by a driving mechanism, and the exact character of this material, the particular size of this material, is not an essential acoustic characteristic. Given a driving force and a certain mass of weight or vibrator which is to be vibrated, we must have an adjustment of the power to produce vibrations of the proper frequency and amplitude.

If we have ample facilities at our disposal, we can construct a satisfactory loud speaker in a great variety of ways and I think we can make many of them such that the musical characteristics, the tone quality characteristics of one of a particular shape would be the same as that of another one of very different shape. The main point is that a paper cone 9 inches in diameter or any other specific dimensions is not an essential characteristic.

MR. DARBY: Because of the fact that my handkerchief was probably soiled, I will produce a sheet of cloth which I can offer in evidence to illustrate the fact that it is not a vibratile sound-producing material.

(Demonstration with cloth.)

MR. DARBY: I offer this sheet of cloth in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 21.")

MR. DARBY: It is hereby stipulated that the three depositions attached hereto, being the testimony of the persons named in the cause entitled "Lektophone Corporation versus Western Electric Company, Inc., in Equity 30,234 in the United States District Court, Southern District of New York," and the exhibits identified by the said persons, and introduced in the said cause, and the Exhibits A and B may be used by the defendant in this cause, with the same force and effect as if said depositions and exhibits were regularly taken and introduced in this cause.

It is further stipulated that the total manufacture of loud speakers—using the diaphragm of Defendant's Exhibit D for identification, by the Victor Talking Machine Company did not exceed 40,000 and that none have been manufactured or sold except in the years 1925 and 1926, and it is further stipulated that if any testimony in addition to that stipulation is offered, that I will produce the witnesses Mr. MacEwan and Mr. Diehl for further cross-examination by Mr. Davis, at his request.

MR. DAVIS: Yes, that is stipulated.

DEPOSITIONS OF EDWARD K. MacEWAN, ALBERT C. DIEHL AND HARRY O. SOOY, INCLUDED BY STIPULATION (TAKEN IN 1926).

EDWARD K. MacEWAN.

EDWARD K. MacEWAN, called as a witness on behalf of the defendant, being duly sworn, testified as follows:

DIRECT EXAMINATION.

My residence is 6334 Woodbine Avenue, Overbrook, Pennsylvania, and I am secretary of the Victor Talking Machine Company. Our plant is located at Camden, New Jersey. I have been employed by the Victor Talking Machine Company since 1900.

In 1909 I was assistant to Mr. English, who had charge of the experimental laboratory, and my duties principally at that time were the manufacturing of the recording material and assisting Mr. English in clerical matters.

The structure now shown me is a machine that came over to the laboratory, to the best of my knowledge, that is the same machine that came over to the laboratory of the Victor Talking Machine Company in either the latter part of 1908 or 1909, the early part of 1909. It is a Lumiere machine. I heard this machine played in 1909. Well, I considered that it had a very much broader tone of reproduction than what machines we were making at that time. We were making the horn type machine going underneath the motor and enclosed horn at that time, enclosed horn and sound box machine and phonograph.

I note that the diaphragm on this machine is a pleated paper one. Subsequent to my hearing this machine in 1909, the Victor Company experimented and conducted experiments with diaphragms of that type.

The purpose of that experiment was trying to accommodate it to the product that we were making at that time. In the early experiments, as I recall, the diaphragm rested on the turn-table, but their object was to try to make it more accessible for use, more convenient, and they later on developed a machine in which the diaphragm was placed in an upright position. When I say convenient, I mean, to get it away from the turn-table.

The Victor Company is making devices today with these pleated paper diaphragms. They are making a loud speaker for radio purposes. That diaphragm is substantially the same as the one which is on this machine which you have identified.

MR. SCULL: I offer the machine identified by the witness in evidence as Defendant's Exhibit A.

(Marked "Defendant's Exhibit A.")

In making these radio loud speakers with the pleated diaphragm, the Victor Company is doing that under license or other arrangements under patents of Lumiere. They took an option, according to my recollection, in the early part of 1909. That option was taken up. They have a contract.

In the experiments of which I have any knowledge, no change was made in the diaphragm itself on this Exhibit A. That is, the experiments which I mentioned were merely to fit in these large diaphragms into the Victor cabinet machine. And then also they had it so arranged that they could use it on a table type machine.

As secretary of the Victor Company I am fairly familiar with the sales of Victor talking machines. Something over 300,000 of the Victor talking machines of the sound-box and horn type were sold in 1918. In

1919, over 400,000. In 1920 I think we came up to the 500,000 mark.

I heard of the Pathé Actuelle in 1918, 1919 or 1920. I never heard any discussion amongst the officers of the Victor Company as to any effect which the sales of the Actuelle machine were having on the Victor sales.

CROSS-EXAMINATION.

This option with the Lumiere Company was taken up in the form of a license contract, as I recall, around 1909, the early part, with Mr. Lumiere.

The Victor Talking Machine Company manufactured phonographs with this Lumiere diaphragm. I think they sent a few out to the different foreign countries. They did not ever sell any in the United States to my knowledge. I have no idea how many they ever manufactured and sold. It was very few.

It was in 1925 that the company first made radio loud speakers with the Lumiere diaphragm. They are still making and manufacturing those loud speakers with the Lumiere diaphragm under the trade name, Victor Loud Speaker. The Victor Talking Machine Company is not manufacturing and selling devices with radio loud speakers of any other type.

As to whether or not the Victor Company recently offered on the market and showed a phonograph combined with a radio loud speaker, and if so under what name, I do not know of any except that cone that we are placing in what we call our Electrola instrument. That is, our Electrola instruments are the de luxe latest model Victor Talking Machine Company instruments. They have a cone in them. The cone is not manufactured by the Victor Talking Machine Company. It is purchased from the Radio Corporation of America and manufactured by the General Electric Company.

I am not familiar with the type of radio loud speaker, the two types that the Radio Corporation of American puts on the market under the numbers Radiola 100 and Radiola 104.

The size of the cone in the Victor Electrolas is, if I recall, one is 6 inches and the other, I think, is 13 inches.

MR. DAVIS: It is stipulated that in the Victor Talking Machine Company's product known as the Electrola, which is a combined phonograph and radio machine, the radio loud speaker is either a Radio Corporation Radiola 100 or a Radio Corporation Radiola 104.

MR. SCULL: And that these loud speakers are bought as part of the complete radio equipment from the Radio Corporation and this complete equipment is installed in the combined machine by the Victor Company.

MR. DAVIS: And the loud speaker serves as a loud speaker both for the phonograph and the radio receiving set.

MR. SCULL: I will say that when the electrical pick-up is used in such a machine.

MR. DAVIS: The electrical pick-up is a device by which the phonograph records may be utilized to actuate the electrically actuating mechanism of the loud speaker.

THE WITNESS: I do not know how many horn type phonographs were sold by the Victor Company in 1921. I do not know if it was less than 1920. I recollect that 1920 was the largest year the phonograph business ever saw. I know that the business in horn type phonographs in the year 1925 of the Victor Talking Machine Com-

pany was not as large as other years. It was about 400,000, I think, all told. In 1924 it was around 400,000. There has been a slightly progressive falling off in the horn type phonograph business since 1920.

This instrument which has been put in evidence as Defendant's Exhibit A came over to the laboratories of the Victor Company. It was either brought over by Mr. Johnson or it was sent over. It was built in France by Lumiere or under his direction.

RE-DIRECT EXAMINATION.

Horace Petit was the Victor Company's patent attorney. He is now dead.

Mr. Johnson, I just referred to, was the president of the Victor Talking Machine Company in 1909.

At the present time the Victor Company sells phonographs of the sound box type with the horn without any radio attachment. The biggest product is that.

The Victor Company makes what they call a triple machine. One which has an ordinary phonograph horn played by means of the needle on the record. That is what they call a mechanical reproduction. In such a machine or type there are incorporated a radio outfit with a cone loud speaker, the radio reception being delivered through this loud speaker, and there is also in such a machine a so-called electrical transmission or electrical pick-up by which the phonograph record can be also transmitted to the cone loud speaker. In other words, in the one machine there is both the phonograph horn and sound box of the very old type and also the radio loud speaker.

RE-CROSS-EXAMINATION.

I testified that the Victor Company began manufacturing some radio loud speakers with the Lumiere diaphragm last year. I really think they manufactured

about 40,000 altogether. I think we started to make deliveries about either December or January of 1925. No, I do not believe it was quite that early.

As to the way the sales have grown, that is, whether they have been on the increase or the decrase, the sales are not so high just at present. That is true of radio loud speakers generally. It is a seasonal business

The company has not decided how many loud speakers they will manufacture for next year with the Lumiere diaphragm. There has been no decision arrived at at the present time as to quantity.

EDWARD K. MACEWAN, recalled.

DIRECT EXAMINATION.

At the present time the Victor Company is putting out a machine of the sound box and horn type known as the Orthophonic. The great bulk of the business is being done by the real talking machine with the Orthophonic horn and the regular Victrola sound box.

That is not what I call an Electrola, that last machine I have described. The Electrola is the one with the radio combination, and the other one is the Orthophonic. The Orthophonic is by large the major portion of our business, and that is by large the horn type.

I am pretty sure the Victor Company also makes a type of radio receiver in which they use a Western Electric horn for the radio portion. That is the Orthophonic horn. With these radio receivers they are not using the cone loud speaker.

I could not say what percentage of the total business in radio machines this Orthophonic type have to the total amount. It is larger than the cone.

CROSS-EXAMINATION.

What we called the Electrola came on the market—I imagine we started to put them out about February of this year (1926). The price of the Electrolas to the ultimate consumer is about $425, I think, and there is another one about $500, and there is another one about $900.

STIPULATED DEPOSITION TAKEN IN 1926.

ALBERT C. DIEHL.

ALBERT C. DIEHL, called as a witness on behalf of the defendant, being duly sworn, testifies as follows:

DIRECT EXAMINATION.

A. My address is 229 North Thirty-ninth Street, Camden, New Jersey. I am employed by the Victor Talking Machine Company. I have been employed by the Victor Company since 1899. I was away a short while, but the second reinstatement was from 1900.

The machine marked Defendant's Exhibit A I first saw during the summer of 1910. I was called to help Mr. Elfering. He is now dead. I was called in to help him on some mechanical jobs, I having a machine shop and he having no machinery, I used to from time to time do his machine work for him and that is the time I saw this machine and one like it. I heard it played at that time. Mr. Elfering and Mr. Lumiere were present. It seemed to me to have a clear, full tone. I liked it. I thought it was a little more natural than our regular talking machines.

I did not come in contact with Mr. Elfering very often, but as far as I know he was trying to arrange the machine so that it would be more convenient to get

at the record by placing the diaphragm in a convenient position. I did not see very many of the experimental machines that Mr. Elfering made. I saw some.

The diaphragm was always the same in these machines, as far as I know, with the exception that he was experimenting at times with different diameters of that small center making it out of different materials, and so forth, and different diameters.

CROSS-EXAMINATION.

The ton of the Lumiere diaphragm seemed to me more natural than the standard horn type speaker of the Victor Talking Machine Company. As to whether that Lumiere speaker had less of a horn sound than the standard Victor Talking Machine, I should say it was less sharp. More of a natural tone. It had more of the round, full tones, whereas the talking machine had more of sharp, bright tone. I do not know enough about it to know what a horn resonance is in these machines.

HARRY O. SOOY.

HARRY O. SOOY, called as a witness on behalf of the defendant, being duly sworn, testifies as follows (deposition taken 1926):

DIRECT EXAMINATION BY MR. SCULL:

I reside at 265 Myrtle Avenue, Merchantville, New Jersey. I am superintendent of recording for the Victor Talking Machine Company. I have been employed by the Victor Talking Machine Company ever since it was organized. I started with Mr. Johnson before it was organized in 1898. I have been connected with the recording department of the Victor Company since 1900.

The device you have produced is a Stroh violin. This device or one like it came from Europe, I think, in 1903, by Mr. C. G. Childs, who was then manager of the recording department. These violins have been used by the Victor Company since 1904 constantly. We used it at that time because we could concentrate the sound more direct to the recording horn which we were trying to get on the records, while the regular violin spread in the air and we could not concentrate it to get on the record strong enough.

The device which I have in my hand is the same as has been used by the Victor Company since 1904. It is either one or one exactly like it.

MR. SCULL: I offer this in evidence as Defendant's Exhibit B, Stroh Violin.

(Marked "Defendant's Exhibit B.")

MR. DAVIS: No cross-examination.

MR. DARBY: I offer at this time the Lumiere device Defendant's Exhibit D for identification.

THE COURT: Admitted.

(Received in evidence and marked "Defendant's Exhibit No. 23.")

MR. DARBY: I offer in evidence the original Stroh violin which has heretofore been marked as Defendant's Exhibit C for identification for use in connection with the deposition of Mr. Sooy.

(Received in evidence and marked "Defendant's Exhibit No. 24.")

EDWARD K. MacEWAN.

EDWARD K. MacEWAN, called as a witness on behalf of the defendant, and having been duly sworn, testified as follows:

DIRECT EXAMINATION.

I am secretary of the Victor Talking Machine Company.

I am the Mr. MacEwan who testified in the case of Lektophone Corporation v. Western Electric Company.

The Victor Talking Machine Company sold ten-inch cone equipment with its machines in their model called the Cromwell.

The Victor Talking Machine Company also sold cones under nine inches.

The Victor Company discontinued the sale of ten-inch cones.

The Victor Company now sell cones that are smaller than nine inches.

The Victor Company does not now sell cones over nine inches. They do not sell any that are nine inches that I know of.

I have looked up the figures of the number of sales of this various equipment recently.

The proportion of the number of Victor machines of the horn type which were sold during the period, to the machines using ten-inch cones which were being sold I would say was approximately 100 to one.

We discontinued the sale of cones of the ten-inch type about July, 1927.

The proportion made by the total number of Victor machines of the horn type with respect to the number of machines sold with cone apparatus, whether it is over nine inches or smaller than nine inches.

Over the period of time that we were selling cone apparatus was about eighteen to one. That is, all type of horn machines. As to why the ten-inch cone structure or a structure having a cone over nine inches was discontinued.

I cannot say, except that we were not very well satisfied with the performance of that instrument. We are now selling a six-inch cone and eight-inch cones. We are satisfied with the performance of those structures. They are very good. They give excellent performance.

I have recently checked up for Mr. Rich the total number of Lumiere diaphragm devices that were sold by the Victor Company. About 48,000 all told.

We now buy our reproducing apparatus of the cone type from the Radio Corporation of America.

We began to acquire our cone reproducing apparatus from the Radio Corporation of America about January, 1926.

We had a contract with the Radio Corporation of America in 1925.

The Radio Corporation of America supplied us with the ten-inch cone structure.

In June, 1926, the Victor Company discontinued the manufacture of the Lumiere structure.

CROSS-EXAMINATION.

I do not know of the first cone speakers that my company sold, manufactured by the Radio Corporation, were the Radiola 104.

I do not know whether the one that we sell now is the Radiola 106. I do not know much about the equipment. I do not know how they are designated.

The Victor Company call them when they sell them, the super-heterodyne sets of Radio.

The Victor Company now sells more than one size of loud speaker. I think they sell the eight and the

six. That is the Victor Company's designation. That is all I hear them call it.

When I spoke of the diameter of the cone or the size of the cone as being more or less than nine inches, I meant the diameter of the cone across its base.

When I got up these figures in which I compared the total number of cone speakers sold by the Victor Company with the total number of horn speakers sold by the Victor Company, I did not include among the cone speakers the 40,000 Lumiere speakers that the company sold.

RE-DIRECT EXAMINATION.

I am not connected with the sales department of the company.

When I referred to the cones as eight and six, I meant by those figures that the cones that we are using now in our machines are eight inches and they call them the eight-inch cone and the six-inch. That is all I know of the designation.

SELDEN T. WILLIAMS.

SELDEN T. WILLIAMS, called as a witness on behalf of the defendant, and having been duly sworn, testified as follows:

DIRECT EXAMINATION.

I am thirty-seven years old; my occupation is engineer; my residence, is 83 North American Street, Woodbury, New Jersey.

I have been associated for the past three or four years with the Victor Talking Machine Company.

I was originally production engineer in 1923, in 1924 chief engineer; 1927, general superintendent; 1928, works manager.

I am no longer connected with the Victor Talking Machine Company. I left in December 12, 1928.

I know the circumstances under which the Victor Company took up electrical operation and sound reproduction.

At that time, 1922 and 1923, the sale of the mechanical reproducing Victrola was not exceedingly good. And the Orthophonic contracts with the Bell Telephone Companies were about completed and radio was increasing in importance, and radio production was becoming more interesting to the sales and engineering department and the Radio Corporation had developed complete electrical apparatus for electrical reproduction for the radio and the record, and the contract was made with them to secure the electrical reproducing equipment.

The Victor Company was manufacturing only the radio loud speaker. No one name would apply to the rest of the equipment going to make up the complete assembly.

In the radio side there will be the radio receiver and the amplifier with a loud speaker and in the record reproducing side there will be a pick-up control and the amplifier loud speaker.

On the phonograph side, the Victor Company was manufacturing the Lumiere loud speaker only.

They were not manufacturing the remainder of the electrical equipment necessary.

The equipment I now produce is the amplifier used in the Cromwell equipment for the operation with the ten-inch cone. I mean the Cromwell model of the Victor Talking Machine Company.

MR. DARBY: I will offer it in evidence.

THE COURT: Admitted.

(Received in evidence and marked "Defendant's Exhibit No. 25.")

THE WITNESS: This equipment was purchased from the Radio Corporation of America.

The Victor Company was not manufacturing this equipment at that time.

The apparatus I now produce is an amplifier used for the operation of the six-inch cone type speaker.

That equipment was purchased from the Radio Corporation of America.

The Victor Company was not manufacturing any of this equipment.

MR. DARBY: I offer that equipment in evidence, the 6-inch type.

(Received in evidence and marked "Defendant's Exhibit No. 26.")

I recognize this pamphlet that is handed me.

It is a service bulletin on the general information of the power amplifier units.

I find in that service bulletin a picture or schematic layout of the apparatus which we purchased from the Radio Corporation of America and which we were not manufacturing. That covers the amplifier construction.

MR. DARBY: I offer in evidence the pamphlet of the witness, page 3, showing a picture of the electrical equipment.

THE COURT: The exhibit is restricted to page 3 of that pamphlet.

MR. DARBY: Yes, sir.

(Received in evidence and marked "Defendant's Exhibit No. 27.")

THE WITNESS: This is a similar pamphlet. I find a similar picture in that pamphlet showing the equipment on the 10-inch cone.

This diagram covers the 10-inch cone mechanism. There is a schematic arrangement of the power amplifier unit.

MR. DARBY: I offer in evidence page 13 of the pamphlet last referred to by the witness.

(Received in evidence and marked "Defendant's Exhibit No. 28.")

As to the decision of the Victor Company as to the employment of cones for loud speakers in its equipment I was concerned with the various discussions between the sales department, engineering department and various other departments of the concern.

As chief engineer of the company I participated as to the cones that the Victor Company put out. The initial contract called for two types of cones.

Prior to the contract the first type that my company put out was the Lumiere diaphragm. We started the Lumiere speaker as a diaphragm and not a cone. That was the first type of free air reproducer the Victor Company put out.

I recognize this diaphragm as what the Victor Company built and the operating mechanism I do not recognize.

MR. DARBY: The witness is referring to Defendant's Exhibit 16.

THE COURT: He identifies the diaphragm and not the operating mechanism.

MR. DARBY: That is right.

THE WITNESS: As to why the Lumiere diaphragm or the Lumiere reproducer was discontinued, our contract with the Radio Corporation covering electrical reproducing equipment purchased and those supplied us with complete equipment from the point of the needle

to the sound and from the radio impulse to the sound. We bought the complete apparatus.

This was a complete performing apparatus and all parts were balanced to each other and matched to each other for the purpose. There were service factors.

With reference to the question of balance, in any system of transferring energy a proportional arrangement of parts is required for best performance. The cone was matched to the amplifier and so on through the other component parts of the system resulting in a better balanced reproduction.

The question of balance might be compared to the application of balloon tires to an automobile. It would require a change in the spring design, in the steering gear design, and various parts of the chassis in order to get the full benefit of the balloon tires. The same applies to changing any component parts, and reproducing mechanism. Care must be taken to see that it fits into the whole.

That was some kind of acoustic engineering problem as to whether or not the Victor Company was paying royalty to Lumiere for the speakers that it made, it is my understanding that we had a license. The financial arrangements I do not know. I do know whether or not that license required a royalty payment.

The Victor Company discontinued the 10-inch cone structure because sales reception were not particularly good for that model.

Its performance was considered at that time not to be as generally satisfactory as the Orthophonic Victrola and certainly not as good as the 6-inch cone model.

Up to the time that I left the Victor Company from the time that the 10-inch cone was discontinued, the Victor Company did not to my knowledge make and sell any reproducers nine inches or larger.

The acquisition of this reproducer equipment from the General Electric Company was a matter of com-

mittee arrangement and as a member of the committee I endorsed it. I did not know when that endorsement was made that the Radio Corporation was licensed under any loud speaker patents. I was not concerned with that. I knew nothing of the patent situation. I understood only that we were protected by our contract with the Radio Corporation.

I satisfied myself as to the performance of the entire equipment including the electrical equipment and the cone. I recognize the structure that is handed me. It is a ten-inch cone purchased from the Radio Corporation. It is the same type of equipment as is used in connection with the equipment that is in evidence as Defendant's Exhibit No. 25.

MR. DARBY: I offer the defendant's cone structure in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 29.")

I recognize the device now produced. It is the 6-inch cone speaker sometimes styled the Rice-Kellogg speaker, used in connection with the equipment, Defendant's Exhibit No. 26. It is a dynamic speaker. The base put in front of the cone was added by the Victor Talking Machine Company. It is styled a booster and made to operate.

MR. DARBY: I offer in evidence the 6-inch dynamic type of cone speaker.

(Received in evidence and marked "Defendant's Exhibit No. 30.")

When I refer to 10-inch and 6-inch cones, the measurement designates the nominal diameter of the cone member, as I understand it, that is, the outer periphery of the cone being regarded as a base, the diameter of the base.

As to whether the change from the 10-inch cone to the 6-inch cone was requested or required by the Victor Company or was made and presented first to the Victor Company by the Radio Corporation, I have this to say. Our original contracts I believe called for both 6-inch and 10-inch cones. This 10-inch cone was later discontinued on account of sales reasons, and we were not particularly satisfied with it. It made an expensive machine, more expensive machine than that used on the Victrola, and not as good as a 6-inch cone.

Confining myself to the fact that we were not satisfied with the 10-inch cone as compared to the 6-inch cone, or speaking acoustically or from an engineering viewpoint, the reason why we preferred the 6-inch cone to the 10-inch cone was the small reproduction, which covered a more musical range; greater volume, and better quality over the range.

By greater, I mean by that, the sound comes from some thirty-two vibrations per second up to say roughly 8000. Certain instruments may cover only 250 vibrations per second up to say 3800. The 6-inch cone covered a greater proportion of that musical range than did the 10-inch cone.

From the viewpoint of the hearer, that means that you hear lower notes and higher notes, if you get a greater range.

Depending on the characteristic of the cone in general, the 6-inch cone is better than the 10-inch cone. That is what I found.

With respect to volume, the fact that the 6-inch cone was a dynamic speaker unquestionably affected the question of volume.

It is possible to apply more power in the direct manner to the dynamic cone drive than by the lever mechanism of the electro-magnetic unit.

You are able to increase your volume by increasing the power even though you decrease the diameter of the cone. It works out that way apparently.

As to whether or not the present type of Victor loud speakers was a development of the sound reproduction from record, graphophone or some other industry, some other branch of the art, I believe it was a development of the radio art.

The dynamic drive enables you to apply much more power to the cone itself and all of our dynamic cones that were used in production so far as I remember, were of the so-called 6-inch diameter.

As to why the dynamic drive was not used with the larger sized cone, there seemed to be some tendency to rattle in the larger sizes of cone when the dynamic drive was applied and the amplitude of vibration impressed by the dynamic drive was available.

When I say "rattled," I mean some noise superimposed upon the reproduction.

With respect to the ability to record low notes in the recording of phonograph records prior to the adoption of electrical recording, the mechanical recording system possessed material weight and stiffness, but we were unable to record anywhere near the degree of base notes that we were able to reach with the microphone amplifier electrical method of recording.

With records of today which have been electrically recorded, you get lower notes than you did with records made by mechanical recording as distinguished from electrical recording.

The increase of range which we were able to record with electrical recording I would consider a marked increase, particularly in the lower register.

In reproducing from a record, it is only what is recorded that is reproduced, as regards music and speech.

CROSS-EXAMINATION.

They claim to go down on the scale on the electrically recorded records to cover between 35 and 40, but the intensity of the loudness drops off from roughly to 80 or 90 vibrations per second.

The Victor Company on the old mechanical records went down somewhere around 150 vibrations per second, as I remember it.

The 10-inch cones supplied by the Radio Corporation to the Victor, like Exhibit 29, and the actuating mechanism that is on Exhibit 29 is the equipment that is sold by the Radio Corporation generally as Radiola 100, in a housing. The Radiola 100 has been discontinued by the Radio Corporation for general sale.

I believe that they give it some other name now.

The drive and cone of Exhibit No. 29 had a somewhat more musical tone than the other type. It is my understanding that the Radiola 100 is a superseded model of the Radio Corporation, and is no longer marketed.

The dynamic drive and cone which has been put in evidence as Exhibit 30 is the equipment of Radiola 104, as marketed by them.

The Radio Corporation calls that same equipment when they sell it to others than the Victor Company originally the 104 loud speaker.

I do not know what they call it now. They now sell to the general public equipment that the Victor Company puts in its instruments and sells and which you call the 6-inch cone.

It is not identically the same, if you go back through the amplifier and the balance of the electrical equipment.

The cones I believe are identical. I do not know what the Radio Corporation calls it when they sell it.

I do not know what the Radio Corporation calls the 8-inch cone when they sell it.

As to whether the Radio Corporation sells to the general public an equipment comprising a cone and driving unit which is the same that the Victor Company sells, and which I call the 8-inch cone, I believe that they have the same equipment in their housing.

But I do not know what they call it.

The diameter of the cone in the Radiola 100-A I believe was originally in the 100, 10-inch. I do not know what it is in the 100-A.

The diameter of the cone in Radiola 106 is nominally 6 inches. It is my understanding that the 100-A and the 106 are later Radio Corporation models than the 100 and 104.

RE-DIRECT EXAMINATION.

The Victor Company first began to commercially use, that is, record for commercial sale by the electrical recording method in 1925, as I remember it.

The Radio Corporation is selling loud speaker equipment to people other than the Victor Company with a 6-inch cone.

They wanted it commercially for their own dealers and supply component parts to the Brunswick people.

As to whether or not the Radio Corporation is selling 10-inch cone equipment to others, I have lost track of the diameters of the present day. They did at one time.

FIFTH DAY.

In the U. S. District Court,
Wilmington, Delaware,
Tuesday, May 14th, 1929, at 10 o'clock A. M., Daylight Time.

Before: Hon. Hugh M. Morris,
U. S. District Judge.

Appearances: As before.

DAYTON C. MILLER.

Dayton C. Miller resumes the stand.

Direct Examination by Mr. Darby (Continued).

Referring to the last demonstration made while I was on the witness stand which consisted of utilizing various materials and pieces of furniture, as a sound reproducer, that demonstration implied in my opinion that the source of sound which we hear, whether it is considered as the original source or as a reproducing source, consists of matter in a state of vibration.

This matter may be of any kind so long as it is capable of impressing its vibrations upon the air surrounding this vibrating matter. This vibrating matter in the case at hand is referred to as a diaphragm.

The diaphragm may be of itself what is called vibratile material or it may be a more solid mass. It must be set into vibrations so that the movement of the surface of this body will communicate the vibrations corresponding to the sound to the air around it.

The air surrounding it must be set into the corresponding vibrations and to such a degree that the air vibrations which then proceed to the ear, will give a

satisfactory and adequate effect upon the ear, representing the source or the loud speaker.

It is immaterial as to what the size of this diaphragm is, within very wide limits, and the demonstration showed limits between 2½ inches to more than 12 and it may be very much larger, but in any case it is necessary that this diaphragm be put into adequate vibration.

That can be accomplished by a proper adjustment of that which causes it to vibrate, and in the case of a loud speaker in a radio unit or the electric motor which drives it, in the case of the talking machine the needle and its accompanying lever which are connected to the source.

By proper adaptation of the driving force to the body which is being moved, the diaphragm, an adequate reproduction of sound can be secured. It is necessary that the vibrations of the diaphragm be properly transmitted to the air.

In this connection the area of the diaphragm is involved and in addition the driving force so that the amount of energy delivered will be appropriate and this energy must be conserved as much as possible and not allowed to dissipate by leaking around the edge of the diaphragm so that we must either have a baffle at the edge, and if we adjust these various factors the point of the demonstration was that we can secure sound reproduction from almost any solid body which can by any means be put into vibration.

These factors have been known in acoustics from the beginning, they have been known for many years. Certainly it is all contained in such treatises as that of Railey which is more than fifty years old.

In one of my demonstrations I used blotting paper. I changed the point of connection from the edge of the blotting paper to its approximate center and then varied the shape.

The curving of the sheet of blotting paper increased the effective area.

As to the effect acoustically this had on the sound waves, there was no difference in the tonal quality, but the difference is one in intensity or the amount of energy represented in the radiated sound waves.

THE COURT: I got the impression that as the paper was put under a strain by its curving, when it was connected at the center, that there was greater volume probably because there was more rigidity in the paper when under a strain and consequently the vibration was communicated with less force to the surrounding atmosphere. That was my impression and so was I wrong about that?

MR. DARBY: No, sir. I think your impression was correct but there was another factor as I understand it. When you confine a body of air more or less by the shape you were in effect loading the diaphragm by causing the vibration to move a greater body of air more or less confined.

By MR. DARBY:

Q. 206. Am I correct in that, Dr. Miller?

A. May I comment on that?

THE COURT: Help me out in any way that you can.

A. (Continued.) The explanation to the Judge seemed to be quite correct with the exception of the last phrase which I should like to explain. You said with less loss to the surrounding air. Well perhaps there may have been less loss. The main fact is that when curved actually more air was set in vibration than in the first place, not due merely to saving of loss, but due to more sound energy generated. There was more energy generated from the driver when the thing is curved and more sound air involved.

THE COURT: I think the difference between us is my inaccuracy in phrasing my thought.

By THE COURT:

Q. 207. What I had in mind was this, that if the paper lacked rigidity, that is, if it were two-ply, that it did not have the form or did not have the quality necessary to transmit the vibrations transmitted to it through the contracting air; is that correct?

A. That is quite correct but the present point is that the driving motor delivers more energy when the resistance is greater and that the difference is not one of loss but one of actual generation.

Q. 208. Now I have your thought.

A. That is the point I wanted to make. Otherwise the explanation was quite correct.

THE WITNESS: It was stated in the Opinion of the Court of Appeals in the Lektophone v. Brandes case as follows:

> "As we understand the action of the cone in free air, waves of difference frequency are shed or emitted from the cone at various zones, that is to say, all the high-frequency waves pass off into the open air near the apex of the cone, and as the waves become of lower frequency they will not pass off except from the farther out edges of the cone."

The statement is incorrect as a statement of what happens in my opinion.

Q. 212. If you take any particular tone which represents a particular pitch somewhere in the middle scale, if you please, will the part of the cone which gives off or causes vibration of sound wave, correspond to that cone be confined to any particular zone or location on the cone diaphragm?

A. It will not. It will be emitted in general from all over the surface of the cone.

Q. 213. Can you get that particular note near the apex of the cone?

A. Probably.

Q. 214. And likewise near the end of the cone?

A. And likewise from the edge. With greater facility from nearer the edge than near the apex. It comes from all over the surface, the surface breaking up into different node patterns but all parts of the surface emitting sounds for all different pitches.

Q. 215. And is that true for high-frequency tones?

A. It is.

Q. 216. And is it equally true for low-frequency tones?

A. It is.

THE WITNESS: As to whether or not increasing the diameter of a cone increases the low notes that the cone is capable of giving off at its free edge, in my opinion the cone of any diameter or any size can give off the low tones whether it is large or small.

Referring to the structure of reproducer shown in the Hopkins patent and to the radio loud speaker of Fada, for example, illustrated in Plaintiff's Exhibit No. 13, I will point out the essential acoustic differences between the two devices.

The Hopkins device shows a plane periphery, the annular ring around the conical portion which has an acoustic effect. In the Fada device the part surrounding the conical portion is of pliable cloth which is ineffective in an acoustic sense.

There is also the manner of support. In the Hopkins device the cone, the vibrating part, is held in its neutral position with respect to its acoustic vibrations by the annular rim which in turn is firmly clamped between the ponderous rings. It is supported in its neutral acoustic position essentially at the edge. In the Fada structure the cone is supported in its neutral

acoustic position by means of the springs attached near the apex of the cone.

The structural differences between the Hopkins structure and the Fada loud speaker are as follows:

The Hopkins structure specifies that the vibrating portion, the tympanum, shall have a diameter exceeding 9 inches. The Fada structures have diameters, both of them, less than 9 inches. The Hopkins again states that the ratio of height of cone to the diameter of the cone shall be one-quarter, 25 per cent. of the diameter which represents the height. In the two structures of the Fada type the ratios of the height of the diameter, the height is 41 per cent. in one and 50 per cent. in the other of the diameter. I consider that these are mechanical differences only, and are not essential acoustic differences.

With respect to the driving force in the two structures, the patent explains only one driving force to be applied to this diaphragm. It explains its use in connection with the needle running in the groove of a talking machine record. The Fada device submitted has for its driving force an electric motor we may call it of the dynamic type as now commonly used in radio. There is a great difference in the amount of power which can be developed in these two cases.

As to the acoustic properties of any room having an effect on the tonal qualities of reproduced sound. I have this to say, it is a very well known and well established fact that the acoustic properties of a room in which sounds such as speech and music are heard are very considerably affected as far as the hearing is concerned by what we call the acoustic properties of the room.

This effect will apply to the reproduction of speech and music by a loud speaker as well as the original source of the speech or music which might take place in this same room.

In our laboratory investigations of musical tone quality, whether of instruments or of loud speakers, were always used, not always, but we do use in the study of such things, rooms which have acoustic treatment, so that we may study the nature of the sound as it originates largely with the effect of the room itself removed.

In answer to the Court's question this morning, reference was made to the loading of the diaphragm. I will explain what is meant by the expression loading the diaphragm.

Perhaps the simple analogy to ordinary electric motor will illustrate it. A motor of the ordinary kind will run light, as we say, and it requires a small amount of electric energy or power to run the motor as it is doing little work. It delivers a small amount of energy. If that motor is loaded by operating machinery or by driving a fan or in any other way, the amount of energy which the motor will deliver is increased when the load is applied. It will be very largely increased up to some limit of its action so that the amount of energy delivered by the device is dependent upon the load.

This is a very well established dynamic principle in connection with various kinds of drivers such as turbines of various kinds in addition to the motors and it also applies to such devices as a vibrating diaphragm which is delivering sound energy.

In the earlier types of diaphragms as used in the phonograph, these diaphragms had the smaller diameters to which reference has been made, three inches or less, and the amount of energy which they delivered to the air in contact with them was correspondingly small and gave a weak sound.

The sound had probably all the characteristics, the essential characteristics of the tone quality in it, but it was very mild in intensity and it would not

carry far and in the telephone we therefore put it to the ear. Everything was there to reproduce tone quality as we hear in the head phones of the radio or in the telephone, but in order to make it audible over a larger area without the head phones, we had to get it to deliver more energy and we load it dynamically by attaching a horn having the small end near the diaphragm and enlarging outward, and the body of air contained in that horn rests on the center of the diaphragm and it has a load effect and when the diaphragm is loaded under those conditions it delivers to this air a larger amount of energy than when the horn is not there, and that is the reason that the horn amplifies the sound because there is more energy put in the air in the horn and then the horn enlarges in such a way that it delivers that energy to a large body of air and the diaphragm delivers to the horn and the horn to the air outside more sound energy than when that is not present.

Such a loading is essential to a satisfactory operation of the diaphragm. It can be secured by the resonating horn which has properties of its own, but the main thing is the loading. That loading can also be secured in effect dynamically speaking by the use of what we term a baffle, by extending the edges of the movable part of the diaphragm by a surrounding stationary portion which enables the load actually operating on the front to be greater than where the air is allowed to move from front to back and the baffle loads it in that way.

We can secure this extra amount of energy delivered with the horn or we can do it by making the diaphragm larger and keeping the air in contact with it larger in amount and preventing baffling and secure the effect by the increased size of the diaphragm.

In any case we can adjust the various factors so that we get for any given purpose a satisfactory result.

In the Lumiere Patent No. 1,036,529, reference is made or at least the descriptive term is employed in describing the diaphragm structure there shown, "a double cone." This is what I understand by the expression there used.

The Lumiere method of pleating the paper and folding it and then putting it in the circular portion produces a stiffening of this somewhat pliable paper, produces a stiffening in the direction of the axis of the diaphragm, the line through the center perpendicular to it, which has the mechanical effect of giving a large area diaphragm, made of light material and yet having such stiffness that it can be made to operate upon a larger volume of air than would be possible with a flat piece of paper.

The cone that we have been referring to in this case, the simple cone accomplishes the same mechanical device of making the paper formed into the cone comparatively light as respects the stiffness of the material in the direction of its vibratory motion.

When the Lumiere cone is resolved, as we say, iato its effective force components as is shown or illustrated in Figure 10 of that patent, the essential part of the structure becomes two flat cones, base to base, and being thus constructed a large amount of stiffness is secured which accomplishes the same mechanical effect as is obtained with the single cones of the larger height.

As to whether or not the Starling & Cole model cone, Defendant's Exhibit 15, which was played on the phonograph had a fidelity of reproduction. I have this to say when operated a small intensities it gave a good reproduction of the sound.

I would say it was a faithful reproduction. With respect to the felt dampening edge as applied to the

Defendant's Exhibit 15-B of Starling & Cole, I call attention to Defendant's Exhibit 29, which is the cone portion of the Radio Corporation loud speaker supplied to the Victor Company. As to what effect the relatively heavy paper pasted on the end of that cone has on its functioning, the paper stiffens the edge of the cone, to a certain extent, and will allow it to be operated at somewhat greater intensity of sound without producing undesirable results. It loads the edge in a manner very similar to that secured by the piece of felt attached to the Starling & Cole cone, Defendant's Exhibit 15-B.

From an acoustic standpoint it does not make any difference in securing the free edge of a conical diaphragm whether the diaphragm be of large diameter or of a very small diaphragm.

In the Stroh patent structure there is a hinge action in the flat peripheral portion of the conical diaphragm.

As to what difference exists in the hinge portion of the Stroh patent and the hinge portion of the Hopkins patent, I have this to say, as described and illustrated in Figs. 1, 2 and 3, there is present in the Stroh patent one or more corrugations around the edge of the cone connecting it to the flat portion. In the Hopkins patent it discloses the construction in which the flat annular portion joins the conical portion directly without this curved union or corrugated part.

The difference between the two is structural, this curved portion or the corrugation of the Stroh patent will allow the hinge action to take place with greater facility than would take place in the Hopkins method of construction where the junction is that of two surfaces directly coming into contact with one another.

The Hopkins patent would be a little stiffer at the point of junction although in both cases there would be what is called a hinge action.

By THE COURT:

Q. 234. Does that mean that the only difference is one of power or force or energy necessary to produce the same result? The inference I get maybe wrong and that is the reason I am asking this so that you may put me right. I get from the hinge action of Stroh, that it can be operated to produce a specified vibration or result with less force, less energy or less power, whatever the proper term is, than could be done were there no hinged action or corrugations there, is that it?

A. That is the explanation that I intended to make, that there is no essential acoustic difference in this curved part, but that this curved corrugation does facilitate yielding of the rim in order to secure hinge action a little more freely than the Hopkins device does.

THE WITNESS: Referring to the Dann & Lapp No. 338,660, as to what acoustic difference there is between the hinge portion or flat annular rim portion of the Dann & Lapp structure and that shown in the Hopkins patent, there is no acoustic difference in my opinion. There is a slight structural difference. In this Dann & Lapp diaphragm an annular rim seems to be formed out of one continuous piece of material. The Hopkins structures are made with the rim separate from the conical portion, and then the rim portion is bent upward and attached to the lower edge of the conical portion in construction in such a way that there there will probably be an increased stiffness at the point of the Hopkins patent as compared with this one because of the double thickness of the material at the edge of the cone, whereas there is only a single thickness here.

I have been referring to Hopkins structures other than shown in the patent. I confused that.

In the structure shown in the patent, the flat annular rim portion and the conical portion is all made of one piece.

As the drawing shows there is no difference between the construction shown in the drawings of the Hopkins patent and the drawings of the Dann & Lapp patent. I was thinking of the actual cones that I have seen here.

The specification of the patent in suit describes this structure as made in one piece. There is no mention of it being of more than one piece.

Referring to the disclosure of the English Patent No. 1,192,289. As to what difference exists between the hinge structure there shown and the hinge structure shown in the Hopkins patent. I have this to say, the Hopkins patent has the hinge structure made of the same material as the cone and presumably in one continuous piece. The flange, the plane peripheral portion is made of the same vibratile material as the cone itself and in vibration it produces acoustic vibrations which are part of the sound effect.

In the English patent referred to the plane peripheral portion is made of a yielding material such as cork and the hinge action is very similar, but this cork is of very little or of no effect as regards the acoustic effect.

Refer to the English Patent No. 1,064,062, as to in what respect the flat hinge portion there shown differs from the flat hinge portion of the Hopkins patent in its function and structure, I have this to say: The hinge portion, the flat peripheral portion in this instance is stated to be made of rubber which is attached to the edge of the diaphragm and then to the supporting ring. It serves in my opinion substantially the same purpose as the flat peripheral portion of the Hopkins patent with this minor exception, that this

being made of rubber instead of the same material as the cone might, depending upon the character of this rubber, whether thick or thin, stiff or very soft and pliable, might have slightly different acoustical effects, according to what that material is and that is not made plain in the patent.

The cone structure itself in English is provided with a narrow flat peripheral portion to which the rubber is attached and the rubber attached to the supporting ring.

As to whether or not there would be a hinge action between the flat peripheral portion of the cone and the conical portion of the cone in the English structure, it would be negligibly small, so much so that I would say there would be no hinge action.

The hinge movement would be confined to the rubber ring surrounding it.

As to what differences exist between the operation of a diaphragm acting as a transmitter and one acting as a receiver, I have this to say:

The diaphragm in either case must vibrate in such a way that its vibrations correspond to the sound or sounds involved. In one case the diaphragm is given these sounds from the air as a source, as far as the diaphragm is concerned. It is then set into vibration by the air into vibrations which must acoustically correspond to the vibration of the air in any satisfactory use of the device. These vibrations then in transmitting are carried on into the electro-magnetic apparatus which need not be explained, whether telephonic or radio microphone or mechanical device in recording of phonograph records.

When it is used as a receiver, the vibrations are given to the diaphragm from the electro-magnetic or mechanical devices attached to it, causing the diaphragm to vibrate again with exactly similar and

equivalent vibrations as regards acoustic properties, and then those are given to the air itself.

In either case there is on one side, let us say, the air on one side of the diaphragm, and on the other side the electro-magnetic or other mechanical devices. It makes no difference so far as the essential vibrations of the diaphragm are concerned which side is the origin and which is the reproduced side. The diaphragm acts in both cases to reproduce the sound and it does do this in exactly equivalent fashion whether it is air that is impressed on the diaphragm or the diaphragm impressing on the air because in radio transmission we have both actions taking place to such a degree in the microphone for transmitting, in the loud speaker for receiving, to such a degree that we hear from the loud speaker the equivalent of the sounds which were impressed upon the microphone and to the degree to which we are satisfied with that reproduction, it is never ideal to the last limit, and we are always trying to improve it, but to the degree that we are satisfied that we do hear music and speech, the vibration of the transmitting diaphragm and the vibration of the receiving diaphragm are equivalent. That is, equivalent to saying that in general they are equivalent acoustically and mechanically.

As to my familiarity with the transmitting and receiving diaphragms used in the ordinary telephone, I have been studying such things practically all my life and doing it intimately and in the laboratory and it is a very important part of my work.

I am asked in what respect mechanically does the diaphragm by itself in a telephone receiver differ from the diaphragm in a telephone transmitter?

My answer is not at all as far as the acoustic effects are concerned. The diaphragm used for a transmitter can be used directly for a receiver and it was so used in the early days. For structural reasons we

find it convenient to adopt different devices but the results of the vibrations are the same.

Referring to the Maxwell Patent No. 216,051 as to in what respect the plane annular rim portion of the diaphragm there shown differs from the similar structure in the Hopkins patent in so far as the hinge action is concerned, I have this to say:

The general form of the diaphragm and the annular portion is the same. The difference one must judge from the drawing, the Hopkins patent shows a wider annular rim, but there will be a yielding in both cases.

In the two Lumiere patents Nos. 986,477 and 1,036,529, there is distinctly shown a short horn as it may be called marked No. 11 in both patents. This short horn serves more as a baffle than as a resonating horn. It has very little effect as a resonate, but it has a useful purpose as a baffle, preventing the air from the front directly passing around the edge.

Referring to the Lumiere Patent No. 1,182,078, this patent discloses a diaphragm which is connected at its periphery with a sound box which engages the marginal portion 16. Such a sound box would serve the purpose of a baffle in the sense that we have been describing it.

The thin membrane of gold beater's skin marked 10 in the Fig. 2 of the drawing makes the baffle really a baffle by closing up the marginal gap between the edge of the cone and the supporting sound box. It closes that opening and makes it a baffle.

Referring to the Brown British Patent 1157 of 1911. This patent discloses the use of a membrane mentioned as gold beater's skin connecting the edge of the diaphragm to the supporting portion and which forms a baffle and as it is composed of extremely thin and light and resilient matter, it closes the gap and allows freedom of movement of the cone.

By THE COURT:

Q. 251. I want you to explain to me, because I am not sure, and I want to make sure, the acoustical operation of a horn, if that means anything to you. How does a horn operate to give off sound? You gave that to me in part a while ago. I have a theory of my own and I think maybe I am wrong, but will you tell me what that is? What I got in mind is this, it may be entirely wrong and so you can tell me if it is, and that is, that the diaphragm of a horn is what starts in vibration the air contained within the confines of the horn and it is the vibration of the air contained in the horn that starts in vibration the horn cone which adds to the volume or sound of the horn?

A. The latter part I think is not correct. The sound from the horn does not come essentially from the material of the horn itself. It is the air within the horn, the confined air which is the source of further sound.

Q. 252. And the air does not give a secondary vibration of any moment to the substance?

A. No, it does not. Theoretically it should not be made.

Q. 253. So that fact marks the fundamental difference between the Hopkins or Fada device or any other device, I am not trying to compare or distinguish those, and the cone, and I do not want to lead you into a question because I am not attempting now to get any differences between one cone and another, but the cone and the horn, broadly speaking?

A. The cones that we now speak of, I think, should be compared to the diaphragm part of the horn combination.

Q. 254. The cone itself is the diaphragm?

A. It is the diaphragm.

Q. 255. As well as containing, or is it purely incidental in the cone, or mainly incidental, the amount of air contained in the cone?

A. The air inside of the cone has nothing to do with it.

Q. 256. Or not much?

A. It is not a part of the acoustic property. The vibrations from the surface——

MR. DARBY: If I get your Honor's idea, due to the shape of the cone being cone shaped, it has somewhat the appearance of a horn and I think what the Court is asking is whether or not this peculiar shape of the horn makes it act somewhat as a horn.

THE COURT: It is partly that.

By MR. DARBY:

Q. 257. And to carry it a step further, the effect that you have described of a horn, does that partially take place in a cone-shaped diaphragm?

A. I think I see the point the Judge is getting at. I should say in a general answer what I did mention a moment ago that the proper operation of a horn in connection with a diaphragm is one in which the material of the horn itself, the body of the horn, does not vibrate. It is not a source of sound. If it is, and it is not often, when it is, but if it is it is of considerable disadvantage.

By THE COURT:

Q. 258. It would give a discordant note?

A. Yes. It is more apt to absorb some tones out of the music than otherwise, but it is not a part of the acoustic system proper in the sense here taken. The reason that we use the horn is to separate the enclosed body of air, direct surrounding air and that column of air which rests on the diaphragm is itself a vibrating

body, and I could at length tell how it is capable of vibrating in many different frequencies so that it will take them up from the diaphragm and this body of air resonates them, as we say, and then they are transmitted from the air in the horn to the air outside of the horn directly.

The effect of this conical portion in any of these practical structures as regards the effect of a horn is negligibly small and of no effect.

By Mr. Darby:

Q. 259. As a matter of fact, in the radio loud speakers you have sound waves emanating from the rear of the horn structure as well as from the front of the horn structure?

A. Yes, that is true. Whether they become effective or not outside depends on the construction of the housing and so forth.

The Court: I get what you mean now. From the rear of the cone in the radio loud speaker it vibrates the air both inside and outside.

The Witness: Yes.

The Court: And you consider the air within the cone really part of the outside air because it has a negligible effect?

Mr. Darby: Yes.

The Court: I see.

The Witness: I observed in various of the patents that we have referred to, notably the two English patents, the two British patents to Brown and the Elfering patent, that the conical diaphragms are of small diameter and enclosed, and both referred to in the phonographic art as sound boxes. The significance of that term "sound box" I will explain and also tell what difference exists in an acoustical sense in their opera-

tion as compared with the loud speakers, such as the radio loud speakers of Fada.

The diaphragms which you mentioned first are of smaller sizes and they are held and supported in the casing, which is merely a technical term to call that casing with the diaphragm and the needle support the sound box. There is a baffling effect of separating the air on the front side of the diaphragm from that on the rear.

In the radio loud speakers this sound box or housing has been enlarged in the case or cabinet with a baffling effect still present, but as I have said repeatedly, each one of these diaphragms in its proper use is employed for either receiving or reproducing sound vibrations and I have said that they are equivalent and I have explained to what extent and I can only say that we get from any one of these a sound effect which is a representation of the original sound and therefore their acoustic vibrations are essentially alike.

As to why, in the radio art particularly, they employ cone diaphragms or employ diaphragms of six inches or more in diameter rather than the small diaphragms of the sound box type, they employ them because we are going to demand larger volume of sound reproduction which can be conveniently and economically obtained from the larger sized diaphragms according to current practice.

The power available in radio is quite sufficient to operate the devices that we are now making which require quite increased power.

There arise in the elements of broadcasting equipment resonant frequencies which affect the sound delivered by a loud speaker.

I should refer to them in my laboratory work as distortions or disproportionate relations between sounds. They are produced in very many different points and parts of the receiving and transmitting ap-

paratus and perhaps twenty-five or fifty different places in varying degrees.

In some cases sounds that are entirely extraneous of original sounds are introduced, and sometimes sounds given out by the original source of filtered out or extracted from sounds received from the loud speaker, and there are dozens of places where such changes may take place.

My answer again is that we do succeed by ingenuity in the devising of these electro-magnetic devices and so forth, and nevertheless getting a reproduction that we consider acceptable.

I have used both the Fada loud speakers in my laboratory and in my own home.

I should consider that sand patterns made with a Fada cone would properly represent the action of that cone as it would on any other cone to which the method of study was applied.

If I saw sand patterns I would be able to state whether or not those patterns would accurately illustrate the action of the Fada loud speaker as I know it from my study of its operation.

(Witness withdrawn.)

ROBERT H. MARRIOTT.

ROBERT H. MARRIOTT, called as a witness on behalf of the defendant, being first duly sworn, testified as follows:

DIRECT EXAMINATION.

I am 50 years old and I live at 1470 East 18th Street, Brooklyn, and I am at present a consulting engineer.

I became interested in communication without wires through reading of articles about Tesca and

various others while in high school, and in 1897 I went to the Ohio State University and asked for a course permitting me to study communication without wires.

To make the matter brief, I graduated with the degree of bachelor of science in 1901, after having specialized in wireless communication, and became employed by a commercial company known as The American Wireless Telephone & Telegraph Company, putting up stations in New Jersey which were experimental, and I later built in 1902 a station at Catalina and the mainland on the Pacific coast and continued in a construction, manufacture and operation and maintenance of radio apparatus with the commercial companies until 1912, when I became a United States radio inspector in New York and continued that until 1915, when I became expert radio aide with the navy and resigned in 1925 after becoming consulting engineer mainly in radio lines and some in acoustical lines.

I have served as consulting engineer for the Federal Radio Commission.

I made the sand patterns shown on the table in the court room.

The side of this cone is very steep and is about forty-five degrees and of course anything like this would be all right, and you roll the sand down on the side. Therefore, it is necessary to be able to drop something on there so that when this is perfectly still it will stay on there. I found by dropping fine carborundum and dust from about nine or ten inches above the rim of the cone, the particles would distribute themselves fairly smoothly over the cone and down toward the center and when the cone was quiet. Then when the particular frequency that was desired to test was applied to the loud speaker, the cone would vibrate and throw these particles off from the places where it vibrated the most and where it did not vibrate at all

the particles would of course stay where they were originally dropped.

After that was done, getting the results of the throwing off of the particles, I used a spray of shellac, I presume it is a shellac, you make charcoal drawings with it, to hold the charcoal, to hold the carborundum and sand in place.

For creating the frequency of vibration I used an oscillator made by the General Radio Company, of Boston, Massachusetts, which is manufactured for the purpose of testing the various audio frequencies within the musical range and extending somewhat beyond the ordinary musical range.

The cone that I now hold in my hand illustrates that this central portion here, cone No. 1, is marked 60 to 100. That illustrates that this central portion next to the ring where most of the carborundum is off, vibrated very rapidly, throwing the carborundum off with considerable velocity. The vibrations at other places were not apparent in the position of the grains of carborundum.

The pattern that I secured illustrates the vibrations of the cone at from 60 to 120 cycles a second. I could not tell from this device just how low it was.

MR. DARBY: I offer the pattern in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 31.")

THE WITNESS: The cone was set up in the usual way as a part of a Fada loud speaker and was driven in the usual way in the so-called dynamic method.

It was the standard dynamic Fada equipment that was used for that purpose and was simply removed from it.

I will tell you why the frequency was indefinite in the machine which I employed when I got as low as 60 or 100 or 120.

In that particular kind of a device they are operating at the lower end of the scale, where the movement of the condenser that controls the frequency is not very accurate and I did not exactly believe it at that end of the frequency and checked the matter by beats that I got from a 60-cycle alternating current by ear, and it was quite late at night and I did not follow the check up far enough to know whether I was getting a beat of 60 cycles or the first harmonic of 60 cycles or 120, and it is simply between 60 or 120.

The machine checks up above 200 cycles very well with my experience with machines that have been quite accurate on higher frequencies.

The next cone pattern illustrates the vibrations at 400 cycles, the lighter parts being where the carborundum was thrown off and the darker parts being where the carborundum remained.

This pattern illustrates what is termed radial nodes.

That is illustrated by these dark lines here made by the carborundum. Where the carborundum is not present the vibrations take place violently and throw the carborundum off.

MR. DARBY: I offer in evidence the second cone.

(Received in evidence and marked "Defendant's Exhibit No. 32.")

THE WITNESS: The next one was taken when the frequency was 800 cycles and the carborundum being thrown off where the vibrations are violent.

This pattern illustrates the presence of flexual waves.

MR. DARBY: I offer in evidence the 800-cycle pattern.

(Received in evidence and marked "Defendant's Exhibit No. 33.")

THE WITNESS: The pattern at 400 cycles, Defendant's Exhibit No. 32, shows flexual patterns.

This next structure is one obtained operating the device with 1200 cycles. That pattern shows flexual waves.

The pattern, Defendant's Exhibit No. 31, the 60 to 120 cycles, also shows flexual waves.

MR. DARBY: I offer in evidence the 1200-cycle pattern.

(Received in evidence and marked "Defendant's Exhibit No. 34.")

THE WITNESS: The next one is a pattern obtained when operating the device on 1600 cycles.

That pattern also illustrates flexual waves.

MR. DARBY: I offer the 1600-cycle pattern.

(Received in evidence and marked "Defendant's Exhibit No. 35.")

THE WITNESS: The next pattern illustrates the results obtained when the Fada cone was operated at 3200 cycles.

That also shows flexual waves.

MR. DARBY: I offer that structure in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 36.")

THE WITNESS: The next pattern illustrates the results as obtained on 6400 cycles.

That pattern also illustrates flexual waves.

MR. DARBY: I offer in evidence the 6400-cycle pattern.

(Received in evidence and marked "Defendant's Exhibit No. 37.")

THE WITNESS: The limits of audio frequency employed in the reproduction of broadcast sound waves may vary, but usually it is from some place in the neighborhood of 100 cycles and 5000 cycles. There are extreme cases that some pipe organ music may go down very close to 30 cycles or thereabouts, and also some broadcasting stations may broadcast frequencies which represent an audio frequency of 12,000 or more.

By THE COURT:

Q. 32. Is 12,000 on the same basis as your 5000 cycles, or would your 5000 be converted into 10 for purposes of comparison? As you are dealing in 60 to 5000 cycles, then do you mean 12,000 cycles; is that what you mean, or am I all wrong?

A. The higher pitched instrument would produce say 4000 cycles of audio frequency and musical frequency. It is possible that you would have a third harmonic of that produced and the third harmonic might be carried through and radiated by the radio broadcasting station if the broadcasting station is built to accommodate that higher frequency.

Q. 33. Do vibration and cycle mean the same thing?

A. Sometimes when you are talking about sound, they sometimes say audio frequencies, meaning the cycles that occur, or you sometimes say the pitch, and you mean the same thing. If you say 1000 audio frequency you mean that the note has a pitch of one thousand. The two words mean the same thing.

Of course, when you are considering that in air it becomes sound waves in air of 1000 alternating compressions and expansions of air, but in broadcasting and in these devices it is necessary to transfer these frequencies from one thing to another. You have the mechanical devices and electric currents.

Q. 34. I see. Then the audible frequencies in adio transmission range from somewhere around 100 o what?

A. Ordinarily from 100 to 5000, and in extreme ases from 30 to 12,000.

THE WITNESS: The average orchestral piece, I ould say, would be between something over 100 and 800, or something like that. You can call it pitch or udio frequency.

These particular frequencies illustrate that when hese audio frequencies that are represented here from n the neighborhood of 60 to 120 up to 6400 are received s part of the music that they will produce vibrations f these cones similar to what are shown in these sand a ern exhibits.

Sand patterns for the intermediate frequencies ould be of a pattern differing in characteristics omewhere between the characteristics of upper and ower limits of frequencies employed.

For example, a 6400 frequency which you hold in our left hand has a tendency to produce concentric ings and the one that you hold in your right right has a lower frequency, 3200, and that is more or less of a ross between radio nodes and concentric nodes and nything between there would be more on the order f concentric nodes.

I am familiar with the microphones used in radio broadcasting. I have seen a great many of them.

The diameter of the microphones employed in radio broadcasting at stations which I have inspected have a diameter of about 1½ inches of the actual microphone diaphragm or tympanum.

CROSS-EXAMINATION.

Those diaphragms of 1½-inch in diameter are flat. They are made of metal which from the feel of them is quite thin.

This diaphragm does not carry a small coil, in a microphone. The diaphragm is not supported in front on a pole, a magnet pole.

I am thinking of the microphone which has carbon granules.

The answer I gave Mr. Darby was with respect to the diaphragm that drives a little button that compresses the carbon granules in the ordinary type of microphone.

This sand pattern, which is Defendant's Exhibit No. 37, of the cone vibrating at 6400 cycles per second when compared with Exhibit No. 36, which shows the diaphragm vibrating at 3200 cycles per second, shows that there are smaller but more numerous concentric circles in the diaphragm vibrated at 6400 cycles than in the one vibrated at 3200 cycles.

Approximately so. Possibly I better look a little closer at those. These are almost concentric, these lines here, and if extended around there, would be more concentric and these lines here in the 3200 run some towards the center and if I had something going above 6400, it would make circles right around that point there.

The reason that it does not make circles in either one of these two exhibits, No. 37 or No. 36, is, that the radial nodes break the circumferential nodes up so as to produce this pattern which evidences the presence of both radial nodes and concentric nodes.

In the pattern of the 3200 vibrations, I agree that the radial nodes are less numerous and further apart than are the radial nodes in the pattern at 6400 cycles.

The pattern of 6400 cycles is not entirely radial. Part of these are principally concentric and there is nothing radial in that portion there. In that particular portion it vibrates in concentric nodes.

So far as the radial nodes are present, they are less numerous and further apart in the pattern at 3200 cycles than in the pattern at 6400 cycles.

When you look at the Exhibit No. 35 which is the pattern at 1600 cycles, you find the radial nodes still less frequent and further apart than in the 3200 pattern. And more pronounced.

I probably should say that the radial nodes are very evident in the lower frequency of 1600. They are less numerous and further apart?

As you go one step further down the musical scale to Exhibit No. 34, which is the pattern at 1200 cycles, the radial nodes are again less frequent and further apart.

Those radial nodes are usually described as being due to one portion on one side of the node moving down and a portion on the other side of the node moving up, so that the actual movement along the point between the two, is very small in comparison with the amount of movement on either side.

And so constitutes a node between two regions of wide excursion on the two sides of the node. Those radial nodes are due to waves in the material of the cone, which waves are extending circumferentially around the cone.

The waves that I referred to in my direct examination as flexual waves shown on these patterns are waves which have circumferential nodes and which flow radially through the paper.

Looking at the pattern taken at 400 cycles, Exhibit No. 32, this pattern has not any definite circular nodes.

Radial nodes is the only thing that appears definite to me in that pattern.

That is true also of the Exhibit No. 31 taken at 60 to 120 cycles, that does not show any circular nodes.

There is no indication that I see in this particular thing of the circular node but as to moving bodily it does not move bodily of course if there are some portions that move in one direction and some portions in the other.

If I kicked a football through the air that football would move bodily. And the football would simultaneously be undergoing movements of deformation.

In this pattern which I referred to in my answer before the last, that is, Exhibit 32, I did not say that there was not any flexual wave. One portion comes in and another portion goes out.

I am referring now to the radial nodes as covered by the flexual waves.

Mr. Darby in his examination did not use the word "flexual" waves to mean only the waves which produced concentric nodes.

I will call those waves which produced concentric nodes, radial waves.

As I understand it, if we have our terminology correct now, I would say that on Exhibit No. 32 there are no radial waves that appear, but concentric waves.

That means that at that frequency the whole cone is moving without enough flexure to produce radial wave between the apex and the base of the cone.

I have made patterns like this on other cones than these which have been put in evidence.

I have made them on cones in which the cone was supported by an annular rim of paper instead of an annular rim of cloth.

As to how the sand patterns produced on a cone supported by an annular rim of paper instead of an annular rim of cloth compare in general with the patterns produced on these cones which have been put in evidence, I am afraid that is a little bit complicated. I never made tests with cones of a higher pitch or high

angles as that, 45 degree angle, before, with an annular rim of any kind.

The ones that I have tried as a rule are of less pitch, more nearly something like 22 degrees instead of 45. This is about 45.

They also showed this characteristic pattern as the frequency changed; that is, a pattern which at lower frequencies showed radial nodes and no circumferential nodes and at higher frequencies showed circumferential nodes increasing in number as the ferquency increased with a variation in that this change from one to the other would occur at a lower frequency where the angle is less steep.

That characteristic pattern in general with some qualifications was produced whether the cone was supported by a paper rim or by a cloth rim.

As to those qualifications, the ones where they are supported by a paper rim, the patterns went out to the paper rim so that the paper rim would be a part of the whole diaphragm. With the cloth or felt around there, there was no particular indication of what happened on the cloth or felt.

There is only the additional qualification of resiliency and weight.

As to the question of if the resiliency and weight of the cone being equal, would there be any other qualification with respect to the pattern cone between a cone on the one hand supported by a cloth rim and on the other hand supported by a paper rim, I would say that if that was possible, to get the resiliency and weight identical in both cases, the portion inside of the cone proper should be the same thing.

And in any case the general pattern has the characteristic appearance of radial concentrial nodes as the frequency occurs, as a general rule, they would become concentric.

DAYTON C. MILLER, resumes the stand.

DIRECT EXAMINATION (Continued).

As to the accuracy of sand patterns reproducing what actually takes place in a cone speaker and how long that mode of visible representation has been known, I have this to say:

That method of investigating the vibrations of diaphragms, plates and bars was very thoroughly developed and explained in a published book by Chlaidni, of Leipzig, in 1802, and it has been followed by other publications of his, and the method has been a common laboratory method of studying such things and it is considered as being an adequate representation of the formation of the nodes and loops and plates and we have used it in my own laboratory in studying the vibrations of diaphragms an inch and a half and two and three inches in diameter up to and including such things as the sound board of a grand piano and it gives information regarding the vibrations at different frequencies and complex frequencies in the manner that it has been employed in the testimony here given.

I have made hundreds of sand patterns of small diaphragms of telephone size and larger and up to piano sound boards, including every tone on the piano individually photographed in its sound pattern.

I have this to say as to the different characteristics of the respective device that is being employed for making sand patterns:

The device shows the manner in which the vibrating surface breaks up into what we call the node or pattern and it breaks up in different shapes or sizes of areas depending upon the mass of the vibrating diaphragm and upon its thickness and upon the frequency and upon the amplitude of the force to the same extent applied, and any variation in the structure of the vibrating diaphragms such as little internal changes in

the stiffness, changes in the thickness or massiveness of it and in the case of the diaphragms we are speaking of here, these paper diaphragms, modification in the material due to a little greater thickness of the paper or thinness of the paper or the presence of a heavy particle or a thick thread in one place or another or the presence of the joint where the paper cone is fastened together with cement, and all of these conditions will modify the exactness of the pattern so that the pattern is not always, and in fact rarely is perfectly symmetrical.

It may take a variety of shapes and for different frequencies these figures oftentimes assume what seem to be almost capricious shapes and forms. It is an adjustment of the frequency vibration of the energy involved to the particular area of the surface which must respond and reproduce that particular sound.

As to the limits of the frequencies that affect the ear of the average person, if we are listening directly to an orchestra we would hear sounds which would probably vary from thirty or forty vibrations per second up to eight or ten thousand. In the radio reproduction the limits are more apt to be from 100 to 5000 or a little more. The ordinary radio reproducer of the present day does not reproduce either extreme with exactly proper proportion. It fades off a little at both extremes.

The audibility of the ear is commonly stated as starting at sixteen, at the lowest, but a grand piano has for its lowest vibration twenty-seven per second.

The maximum audibility of the ear, as far as it is verified, is about 23,000. It is an acute ear that hears 20,000 and it drops down to 18 or 15,000 with age or lack of sensitivity. The highest tone on the piano has for its fundamental about 4200, but the first overtone will have twice that number, 8500, and that might be

present in orchestral music, but the fundamental tones of the grand piano vary from 27 to 42 or 4300.

In these sand patterns that have been here produced, ranging from 100 to 5000, I understand that the patterns there shown are for those particular fixed frequencies given.

In receiving an orchestral piece with a Fada loud speaker, the cone would vibrate in accordance with the pattern on any one of those individual pattern cones for the frequencies specified.

In actually receiving an orchestral selection by wireless, the tone received is a very complex one containing very many frequencies and these various frequencies must be simultaneously produced from the cone so that we find a single one of these patterns, but we have a composite of many patterns superimposed, but in order to reproduce the audible sound of the particular frequencies specified, we must have substantially the equivalent of the areas indicated in these sand figures vibrating and actually producing that tone. The combination becomes vastly more complicated, but it does not change this statement in regard to these particular frequencies.

Some time this morning reference was made to the difference in sound between 5000 cycles per second and 10,000 cycles per second.

It was spoken of, I think, in connection with the implication at any rate that frequencies above 5000 might be left out of a reproduction of a speaker and it might be thought that that was omitting a very large part of the range of frequencies.

The piano which I mentioned, having its range from 27 to 4200 or thereabouts, represents seven and one-third octaves of music, and the next octave above the higher one would have twice as many vibrations, so that comparing the lowest octaves the number of vibra-

tions would be confined within the limits of 27 and 54.

In the top octave from 4200 to 8400 would only be one octave, and so, while it sounds like a large number of frequencies omitted, it is only one octave and that octave above the octave of the grand piano.

In dealing with the musical effects, we are concerned not with the actual ratio of the numbers of the frequencies, but with the ratio of the numbers one to the other, a geometrical ratio, or as we often referred to it as a logarithmic ratio, and so the numbers in the higher octaves are higher and in the lower octaves it is lower.

The study of the human voice shows that the frequencies of the fundamental tones, the foundation tones of the voice, will range from somewhere around 80 for a very low voice up to perhaps 400 or 500 for a child's high voice.

The fundamental tone in my own voice, as I have measured many times, I consider at 155 is the foundation tone of my natural voice. I have measured bass voices having a foundation tone at frequency of 90. The sounds that enter into speech include the foundation tones of the voice and such overtones that are necessary to make the speech sound intelligible.

A few years ago before broadcasting telephone transmission was so designed that it was limited to a higher frequency of 2200, and that is not quite enough to give adequate transmission of speech.

If the frequency is limited in the neighborhood of 3000, it will then transmit the essential parts of speech. With the advent of radio broadcasting and a much greater interest in the transmission of music over telephone lines, the upper limit has been increased from that limit of speech of about 200 up to varying 4000 or 5000, which gives a very satisfactory transmission for music as well as speech.

I have examined the diagram produced and it represents in a general way the ranges as shown on the musical scale and the musical instruments and with regard to frequencies.

MR. DARBY: I will offer this chart in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 38.")

THE WITNESS: I am familiar with the Western Electric double cone structure. I have examined such a structure. We have several of them in the laboratory where they have been in use experimentally for some time. I have not measured the nodal patterns on that particular structure or a structure of the double cone type.

From my knowledge and experience in the art as to whether or not the same general character of nodal patterns would there be obtained as are obtained with various other diaphragms which I have mentioned, my general opinion would be that they would be certainly formed in accordance with the general principles which we have been explaining.

Referring once more to the Hopkins patent in suit, 1,271,529, and particularly to the passage beginning at page 2, line 109, as to what I understand to be meant by the bodily movement of the cone there described, I should interpret the bodily movement of the cone to mean that all parts of the cone, all of the material constituting the cone moved back and forth in parallel straight lines through equal amplitudes of movement simultaneously. It is what is sometimes referred to here as a piston movement or a plunger movement. The bodily movement as I should interpret it there is this simultaneous movement of all parts together. It is not a fact that no bodily movement takes place in the Fada cone structure in operation. I should say that some bodily move-

ment occurs. Bodily movement with the suppression or elimination of wave movement does not take place in the defendant's structure as it is used in the reproduction of speech and music or as it is used as a radio loud speaker.

CROSS-EXAMINATION.

What I mean to say, is that the defendant's cone does move bodily, but the bodily movement is accompanied by wave movements in the material of the cone, wave motions which are essential to the reproduction of the sound and music.

I said in my testimony today that the Hopkins patent says that the altitude of the conical portion should be one-quarter of the diameter of its base. I thought I was speaking correctly, and if not I should like to correct it, to what is stated there. It says the altitude of the conical portion of the tympanum should be at least one-quarter of the diameter of its base. I agree that in the defendant's cone the altitude is not less than one-quarter of the diameter of the base. So in that respect I think it complies with the statement of the patent.

I said in my testimony that the Hopkins patent discloses a cone having a rim which has not concentric corrugations in the rim. I said that in connection with the discussion of the Stroh patent.

This Hopkins Patent No. 1,271,529 discloses the idea of putting concentric corrugations in the rim.

It says it is possible to form radial or concentric corrugations in the plane peripheral portion.

Concentric corrugations in the plane peripheral portion would increase the flexibility of the rim.

In my testimony yesterday I referred to the amplitude of vibration of sounding bodies and said it was a factor in the volume of sound.

I referred to the pitch of the sound and identified it with the frequency of vibration.

The patent here in addition to referring to the amplitude in the pitch refers to the timber of the sound.

Timber means what I more commonly call tone quality. Sometimes it is called tone color. The timber of the sound depends upon the composition of the sound when it is considered as made up of partial tones, fundamental and its harmonic overtones, and the various combinations of that kind determine timber or tone quality as used in distinguishing the tone quality of one instrument from some other musical instrument or one voice from another.

For example to reproduce the timber of a violin it is necessary that the reproducing body should have vibrations which represent not only the base tones but also the overtones of the violin.

It is necessary that those tones be reproduced in substantially the same relative proportions as they are produced by the violin.

For a good musical reproducer it is desirable not only that it should reproduce tones over the range which I have already discussed but that those tones should be reproduced over that range, each tone in substantially the same relative volume to the other tones as occurs in the original music.

It is a fair statement that it has been the continuous effort of builders of certain reproducing devices to increase the range of the tones reproduced in the first place, and to reproduce them with faithful comparative volumes throughout that range.

That has been the aim of those concerned with the essential acoustic qualities of such instruments.

On this chart or diagram of mine, Defendant's Exhibit 38, the legend here Tuber Base Viole which appears at the frequency line 40 means that that note on the Tuber Base Viole has a frequency vibration of 40 vibrations per second.

Where the kettle drum appears opposite the numeral 48 it means that its frequency of vibration is 48 per second.

That chart was used to illustrate the explanations which I was making and is not a chart of absolute determined frequencies.

Where it says Cello with a dash and the words Base Singer opposite the line 64, it means that a Cello or Base singer emits that frequency note. And the Base Clarinet 70, and the French horn 86.

Those are the frequencies of the lowest tones which those instruments properly produce in musical performances. There are other frequencies from that point up to a higher limit indicated on the same chart.

It is my opinion that there are very few loud speakers of the present day which will emit the tones much below 100 frequency with the proper proportion. They do allow some small part of it to get through and we hear that. By proper proportion I would say 50 or 60 per cent. of the proper amount, and I do not think that is going through.

The constant effort has been and still is to include those tones. That is a desirable end.

I think I should not say the constant effort has been, because I think it is possible, but in doing so it might lead to a cumbersome structure which will have disadvantages in being so large and awkward that they would prefer to make a compromise and sacrifice something of the desired ideal for other reasons. That certainly has been the case in manufacturing in the past, but the person actually interested in the reproduction, the scientific or experimental man would certainly make the effort to increase this covering capacity.

I have given an illustration twice, in my testimony of the modes of vibration of a sound producing device and a sound receiving device. As to whether

or not I have taken the position that because the diaphragm of a pick-up microphone will vibrate accurately to sound frequencies when excited by certain waves and air that it results from that that that same diaphragm can be vibrated by electrical energy to reproduce those sounds in air. I would say that is substantially the idea that I have in mind, but the idea that I did intend to convey was perhaps a little more general than that. It is to the effect that the microphone diaphragm must possess in its movements all of the essential and actual vibrations of the acoustic impressed in so far as those effects are reproduced at the other end. And therefore, it must have vibrations that are the acoustic equivalent of the vibrations which are reproduced at the reproducing end in so far as they are acoustically present and I said in both cases that that was covered by the degree of satisfaction which we have in the reproduced sound and is limited by that degree of accuracy which we hear.

There may be some vibrations that we do not hear and those do not interrupt us in the acoustic reproduction.

That is, I say that both the devices, that is, the diaphragm used either as a sound receiver or as a sound emitter, the devices must vibrate according to the sound.

And I went on to say that it makes no difference which side is the originating side and which side is the receiving side.

I said that and I repeat that the essential characteristics of vibration in the receiving diaphragm and the transmitting diaphragm, that the characteristic of a sound that you get from a diaphragm were produced in the first place from the transmitting diaphragm, therefore, the diaphragm which is used as a transmitter is capable of vibrating in the same characteristic manner as is the diaphragm which is used as a receiver.

If we had a receiving pick-up microphone in this oom and you discharged a pistol in the room the nicrophone would pick up that sound and generate n electric current wave corresponding to that sound n the electrical system.

The diaphragm of those pick-up devices is a flat liaphragm as far as I know. I stated in my previous estimony that it might be as much as three inches in liameter. I have used them. Some one and a half. I nave one in my laboratory now which is nearly three nches in diameter as well as the smaller size.

I do not think I can take that microphone dia- hragm and vibrate it in this room so as to reproduce he sound of the pistol shot when it is a part of the eceiving microphone. But I can have a diaphragm rranged in some fashion, a diaphragm in a trans- nitting device which would reproduce the sound.

Suppose I take the flat diaphragm just as it is in he pick-up, supported by annular rings.

As to whether or not I could vibrate it to repro- duce the pistol shot I would have to answer that I could not use a receiving microphone as a reproducer without reconstructing the instrument.

You can construct a device that would have some way of vibrating at its center. You can take an elec- trical current that had been produced by the micro- phone pick-up and apply it properly to the center of a similar diaphragm to vibrate that diaphragm.

I should say that would reproduce the pistol shot because I should say that in the sense I am talking about, that is what happens in a telephone receiver, that the diaphragm is so vibrated by means of the electric current.

When I speak of the telephone receiver I am talk- ing about producing sound when the receiver is held up to the ear, but it will be produced even if it is not held up to the ear.

I can visualize this flat diaphragm mounted in annular rings. You state it is a thin diaphragm from one and one-half to three inches in diameter and nothing else. You agree that you can vibrate that diaphragm with electric current corresponding to these sounds.

When you say "with nothing else," I do not know what you mean. If you mean literally nothing else you cannot do that. You have to have a magnet behind it, you have to have the telephone receiver, you have to have a device that is competent to vibrate a diaphragm.

If I assume an actuating device, then my answer is yes, it will vibrate and reproduce the quality of sound.

Not necessarily the volume. That depends again on the device and the power available and so forth. Ordinarily a telephone receiver will not reproduce a loud volume. It does reproduce the quality.

If you took the center of that diaphragm and drew it into a conical shape as in these little sound boxes of the prior art, it would have no effect on the quality of the sound.

It would probably require a different amount of driving force to operate it because of the increased stiffness in the diaphragm itself.

As to whether it would be a better or worse sound reproducer I do not think it would change the quality of the sound. If you took everything exactly the same except that you stiffened the diaphragm by conical means or otherwise, and you had the same driving force, the stiffer diaphragm would have the proper quality of sound but less volume.

It would be capable of producing a louder sound with the adequate driving force to do that thing.

That is because the curvature of the cone increases

the stiffness of the diaphragm and therefore causes more area of the diaphragm to move without flexing.

Let us assume that that diaphragm is three inches in diameter, and with no baffle, and you vibrate that three-inch cone with ample power and no baffle, you ask me what would be the effect? In other words, what did I mean by saying that the air will leak around the edge of the cone?

I mean to say that when the surface of the cone moves forward so as to produce a certain amount of compression in the air in front, the air is a fluid, an elastic fluid, and the increase in pressure on the front due to the forward movement will cause some of the air in the front to flow around the edges of the cone and take its place behind and in the forward movement there has been left a sort of rarefaction, as we call it, and the air from the front would move around the edge to the back and to that degree would neutralize the effect of the forward movement of the diaphragm and lessen the volume of sound radiated to a distance from the front of the diaphragm.

That is the compression wave that would be started in front of the cone, as it moved, would be partially neutralized by the air running into the depression or rarefaction behind it.

We will assume that we vibrate that cone at 4000 cycles per second in the one case and at 100 cycles per second in the other case. That neutralization due to the lack of a baffle would be a larger proportion of the effect for the lower frequency and more time is available for the neutralization to take place in each vibration.

Without a baffle a small cone will reproduce the higher frequencies better than the lower frequencies.

For a cone three inches in diameter, and we will say having an angle of inclination of thirty-five or

forty-five degrees made of the same kind of paper that the defendant's cone is made, as to whether or not for frequencies like 4000 cycles per second, that the cone would move substantially without flexing, a three-inch cone, I have this to say:

I think there would be some flexing but not as large as in a larger cone, but at 4000 there would be flexing in a cone three inches in diameter. It would again depend on the amount of power applied on the amplitude of vibration.

I have not heard the loud speakers manufactured by the Radio Corporation referred to here as Rice & Kellogg loud speakers.

As to whether or not my attention has ever been directed to a paper entitled "Notes on the development of a new type of hornless loud speaker," by Chester W. Rice and Edward W. Kellogg, of which you show me a copy, I am not familiar with the paper. I may have it in my files, but I am not familiar with it at sight.

I am not personally acquainted with those engineers. I am not directly acquainted with their professional standing.

I am not familiar with their contributions to the arts.

In a recent answer I said that the cone I thought would flex somewhat at 4000 cycles if it were three inches in diameter but not so much if it were a larger cone.

When you impress these vibrations on the apex of one of these cones, the apex starts to move forward, compressing the air in front of it.

The paper of the cone, having some flexibility, bends somewhat, so that as you recede toward the edge of the cone the paper towards the edge does not follow in exactly the same time as the apex moves; it lags behind it.

That would be a correct statement for certain low frequencies with certain perhaps small amplitudes of vibration. For single pure frequencies it might move in the fashion that you have described.

That is, as you move the apex of the cone owing to the flexibility of the paper, the cone would flex.

I mean that the amount of flexure and the point or points at which flexure occurs would depend upon the frequency of the vibration and its amplitude.

I would say the lack of the flexure as well as its mere size.

These radial waves giving rise to circular nodes that are shown here in the sand patterns are the reflection of that flexing of the cone.

That is a part of the explanation, but when the material is vibrated with certain frequencies depending upon the stiffness of the mass of that material, that particular frequency with a certain driving force is capable of setting in vibration only a certain area of this cone, and if the cone is larger in area than that particular area in order to take up those vibrations it must divide into numerous nodal areas, each of which then has the frequency impressed upon it. That is, it must flex. That is a nodal line.

I agree that with a small cone, I have spoken of one three inches in diameter operating in free air without a baffle, a given range of sounds would be produced better in the high frequencies than in the low frequencies.

With a larger cone the tendency as a general thing would be as the cone got larger to produce the low frequencies in more even volume.

I have explained how it is that impressing a sound on the air with one of these little surfaces there is this slippage or leakage of the air around the edge of the cone which neutralized to some extent the production

of sound. That is due to the elasticity or fluidity of the air.

That is, in transforming the electrical energy which is applied to the cone into sound energy, you encounter this difficulty arising out of the elasticity or fluidity of the air which tends to neutralize the sound produced to the limited extent around the edge of the cone.

When you are considering a pick-up device, a microphone, where the sound vibrations of the air strike the cone or whatever surface it is, and it in turn moves some element which varies or creates an electric current you encounter that difficulty arising out of the fluidity of the air in the same manner. I will explain why the air wave striking this diaphragm passes right around the edge into the back side in exactly the same way.

When you are using the device as a pick-up, you are transforming the energy of the waves in the air into electrical waves. As to whether or not when you are transforming the energy of waves in the air into electrical waves you there encounter this difficulty due to the slippage of the air, my answer is "yes," because when the air wave from the voice strikes this diaphragm, the purpose is to have the maximum amount of energy operate to move this.

If the air wave comes up against the diaphragm on this side and slips around to the back side and keeps this from being pushed forward as much as it would, and in an analogous manner and in exactly the same degree as in the first case.

You have there a sound wave striking the surface, a sound wave in the air, of large area already, filling the room, and the only part of it which is transformed into electrical energy is the part that strikes the surface of the pick-up.

If that is enough to move the pick-up it produces the variation in or generates the electric current which is amplified and sent over the line.

I agree that a very small area exposed to the air waves resulting from a pistol shot in this room would be sufficient to move a pick-up so that it would make a variation in electric current which could srbsequently be amplified by known amplifying means and so made into an effective telephone current.

These condenser microphones that they use in radio today are open to the air on one side and closed to the air on the other.

There are no baffles extending out radially beyond the supporting ring, but the mounting is such that that leakage around the edge does not occur.

As to whether or not I know why it is that the defendant here has manufactured its loud speakers with cones of the size shown by the exhibits here instead of using the little cone, say two and a half inches in diameter, such as I demonstrated here the other day, I can only say that I presume that in their experiments with the thing they found the one they have chosen more acceptable for the purposes for which it is manufactured. I have no direct knowledge whatever.

Referring to the device that I demonstrated, that is Defendant's Exhibit 8, its diameter is approximately two and a half inches. The box in which it is mounted constitutes at once a baffle and resonator.

MR. DAVIS: Mr. Darby do you agree that that driving mechanism is a Peerless unit?

MR. DARBY: Yes.

THE WITNESS: The back cover of this box of Exhibit 8 is quite heavily padded. I do not know what the purpose of the designer was by putting that in. I had nothing whatever to do with the design or construction

of this device. That is equally true of Defendant's Exhibit 9. I have had nothing to do with the design or construction of any of these exhibits.

Yesterday in my direct examination I pointed out that the defendant's driving unit was a so-called dynamic drive and I also pointed to the fact that in this dynamic drive the coil which lies in the magnetic field is mounted on the end of the cone on a small tube, so that the tube truncates the apex of the cone.

I did not intend to convey to the Court the idea that this dynamic drive in that arrangement of the coil on the end of the cone was original with the Fada Company. That dynamic drive has been used many years.

You ask me to turn my attention to the various patents and publications that I have been asked to discuss and tell you whether I find in any one of them this mechanical combination, a conical-shaped paper device impressing sound directly upon the air, that is, without the interposition of a sound-box and horn, provided with flexible edges and coupled to a rigid frame. My answer is yes, I think you will find that construction in numerous of these patents.

The two patents by English are paper cones connected with the solid mounting by flexure surrounding ring. They may or may not produce the sound directly on the air without the interposition of a sound box and horn.

The English device is an ordinary phonograph sound-box. As it is used here it is used in connection with a horn.

As to whether or not I can find any device among these patents, not a sound-box and horn device, but a direct acting loud speaker which has a conical shape and is provided with flexible edges coupled to a rigid frame acting in free air, I think they were not so designed originally. They were designed to be used in

connection with a horn or with a sound-box, and where they are coupled to the edges.

You have on the table before you one of the diaphragms and supporting frame of defendant's loud speaker. It is setting on the table with the open end of the frame, that is, with the base of the cone resting on the table, and the cone standing vertically. It is disconnected from the driving unit. Those brass springs that you are pointing to are the springs that I referred to as maintaining the position of the cone. The cloth rim supports the cone in the position that it now is.

You are pressing down on the edge of that cone. I observe that it moves downwardly. You take up the pressure. I observe it moves upwardly. It returns to its neutral position. The cloth rim caused that. I agree that in the operation of this cone, the rim yields so as to permit the movement of the cone as you are illustrating there.

When I said that the rim of the Fada cone is ineffective in an acoustical sense, I had in mind in that answer that it was not effective in generating sound waves in the air. When I said it was not effective in the acoustical sense I meant that the cloth rim itself produces no effective sound. I think it produces a sound that would be inaudible and would have nothing to do with what we hear from it.

As to what I meant when I said it did produce some sound—when I spoke in that way I meant that sound would be any kind of a wave motion in the air of any sort, even a minute sound or a confused sort of a sound. I did not say that the rim did produce any sound.

The point of my assertion is that the cloth rim of the Fada cone is not made of a vibratile material. It serves as a baffle.

In the device illustrated in the drawing of the Hopkins patent, the flat annular ring serves as a baffle.

In the same sense the porosity of this cloth rim of the Fada structure that you spoke of is not sufficient to prevent it from serving as a baffle.

RE-DIRECT EXAMINATION.

A device operating with a frequency as low as 50 cycles per second or thereabouts as a plunger or a piston would not represent what takes place when it is operating for the reproduction of broadcasting speech and music.

I was asked if any of the patents of the prior art showed a combination of three elements comprising a conical-shaped paper device provided with flexible edges coupled to a rigid frame used in free air. I call attention to the Dann & Lap Patent No. 338,660. There is there shown a conical device. It is coupled with a rigid frame. This is employed in front of a box enclosing the device and in that case it would not be in free air.

In a similar case the Fada loud speaker, enclosed in its cabinet, would not be in free air.

I call attention to the Maxwell Patent No. 216,051. That is a conical device shown. It is coupled to a rigid frame. It is not used in free air. The air is substantially confined the same as is the case in the Fada loud speaker in its cabinet.

I call attention to the Lumiere Patent No. 1036529. There is there shown a device which is described as a conical device. With a special meaning to the word conical. It is described as a double cone.

I call attention to claim 21 of the patent. It is stated to be arranged to be substantially in the form of a double cone. It is coupled to a rigid frame. It is not used in free air in the sense of the term free air that I have been employing in connection with the other answers, because of this surrounding short horn which I have described as a baffle.

Mr. Davis took a cone which has not been marked in evidence, which is a Fada cone and which is demounted from its support and exerted substantial pressure on the end, and asked me if it returned and also what caused it to return. I perform the same experiment that Mr. Davis performed and as at present mounted that cone comes back to its normal neutral position as compared to the Defendant's Exhibit No. 3 with respect to its mounting.

The cone, Defendant's Exhibit No. 3, is in its normal position slightly displaced by the action of the spring supporting the center so that the springs combined with the other determine the neutral position.

As to the mounting of the cone with which I performed that experiment, I have this to say: In this one the only force restoring this is the force of the cloth rim. In the other one there is a combination of the two forces.

In the cone mounted for operation it is evident that the springs are under tension as they stand, and that tension is produced by the mounting at the rim.

Therefore, the cone is slightly displaced in its normal position by the cone of the spring combined with the restraining action of the cloth rim, whereas, in the experimental one the cloth rim only is acting.

The free position of the demounted cone is not the normal neutral position of the cone mounted for use.

In general that would be the statement.

RE-CROSS-EXAMINATION.

The things I have referred to as the springs are the three metal arms of brass that project from a collar around the tube at the center of the cone.

As to the primary purpose of putting those things in the Fada speaker, my impression is that the purpose is a double one, one to hold the wire ring in its

central position in the magnetic field and the other to assist in restoring the cone in its normal position because in continued use and various conditions, the cloth rim will in many cases be much too slack to determine a satisfactory neutral position alone and the springs are required to make a definite normal neutral position for the vibratory motion. The two effects are combined and constitute the purpose of these brass springs.

The tube on the cone which carries the wire coil projects into an annular air gap in the magnet of the dynamic drive.

That annular air gap is of rather small dimensions and rather closely fits around the tube.

The tube has to be accurately centered in order that it will not scrape against the magnet poles as it moves back and forth.

That is an essential and desirable condition.

Looking at the Dann & Lapp patent for a moment, that device is a telephone transmitter.

You are intended to speak into the mouth itself, B.

That board which is shown in Fig. 1 and which has hinges on it, I recognize to be the usual door of the old-fashioned telephone box, where you would have to turn the crank and the mouthpiece was in the door of the box.

As to what was probably the diameter of the smaller end of the mouthpiece B in those devices, I can only surmise, but I should take it to be one inch.

If the constructor built the devices according to the instructions of the patent, lines 38, and following on page 1, the patent says that "It shall equal and even slightly exceed that of the contiguous inner end of the mouthpiece B, of which it forms practically a conical extension." If the constructor followed those instructions, the cone would equal or slightly exceed an inch in diameter.

Turning to the Maxwell patent, that is the device hat has been reproduced and offered in evidence, or hat is the device of which Defendant's Exhibit No. 12 s said to be a reproduction.

I have not seen the device of Fig. 2 reproduced.

I do not know whether or not the device of Fig. 1 s the thing that is patented in the Maxwell patent.

As to where in the patent I find any justification or a device like Exhibit 12-A which has only one dia- hragm, my understanding of that is that it is a demon- tration of the manner of forming the phonic dia- hragm in the manner described in this patent which onsists of a membrane, soft and pliable, fastened to hole in a board and then stretched by a weight and llowed to dry, in that manner forming a phonic dia- hragm and this is a demonstration of how a diaphragm nay be formed in that manner as well as in other man- ners that they have illustrated.

I do not find in the Maxwell patent any disclosure f any device which has a single diaphragm.

I refer to the statement on page 2 of the patent as ollows: "The vibrators are stretched and held taut y means of the button e on the wire T; and but for he button i on the wire outside of the box the vibrators would collapse when the wire was relaxed."

I am asked if the vibrators in this Exhibit 12 are f that character. My answer is, the two vibrators are in that case held taut by a wire connecting the two which stretches them both at the same time and one against the other. In this case they are both stretched against the side of the box by the outside button i.

These vibrators in Exhibit 12, if they were not held taut, would collapse in the sense that this would collapse because they are both made of flexible mem- brane which is stretched under weight and then dried and hardened in their place.

This device in Exhibit 12, if you unfastened those wires, would not collapse, using the word collapse in its ordinary sense.

I have not seen sand patterns made on the Western Electric double cone.

I said that that Western Electric cone would have these vibrator motions which give rise to the sand patterns, that is, the material of the cones themselves would vibrate.

I expressed it as my expert opinion that such vibratory nodal figures would be produced on that cone.

Assuming that the cone is moving in a rectilinear movement back and forth, but at the same time is vibrating or fluttering with these movements that are shown in the sand patterns, the sand pattern would not show directly whether there was a rectilinear movement, that is a movement of translation of the cone as a whole or not.

When you ask me whether the Western Electric cone, when it was vibrated to produce sound, there was any bodily movement of the front cone as a whole, I understand the meaning of the bodily movement of the front cone as a whole.

And I would understand it not to necessarily exclude accompanying wave motions.

I would think it was broad enough to cover a bodily movement whether with or without accompanying wave motions.

You ask me whether in that sense I would agree that in the use of the Western Electric double cone as a loud speaker, there was no bodily movement of the front cone as a whole. My answer is, I should think there might be bodily movement of the front cone as a whole, certainly.

I understand what you mean when you speak of the joint between the two cones.

That is the base at the edge. That joint could act as a hinge and does act as a hinge.

I would not regard it as rigid and inflexible.

MR. DAVIS: That is all.

RE-DIRECT EXAMINATION.

I will refer to the Maxwell Patent No. 216,051. The second paragraph of the first column makes reference to a earlier patent of Maxwell.

MR. DARBY: I offer in evidence the Watts and Maxwell Patent No. 237,712 of February 15, 1881, not as an anticipation, but as showing the state of the art.

(Received in evidence and marked "Defendant's Exhibit No. 39.")

By THE COURT:

Q. 461. May I ask just one thing which I realize is outside of possibly this matter, but I am wondering what the witness would do with regard to the Fada devices here on the bench if there were a substantial amount of slack in the cloth at the outer edge of the cone. Would it serve effective as a baffle in the first instance?

A. Yes.

Q. 462. It would make no difference as a baffle?

A. No.

Q. 463. Would there be any difference in the volume or the quality of the tone given out by the Fada cone?

A. There would be no difference in the volume and certainly no appreciable difference in the quality.

MORTON ARENDT resumed the stand.

CROSS-EXAMINATION (Continued).

I will mark on this drawing, Exhibit No. 5, the distance of the diameter of the opening caused by the metallic ring in the Fada speaker.

I will call that distance dimension g. g in one case is equal to 6 25/32 and that is the small speaker and g on the larger speaker is 8¼ inches. I believe that you will find that this is substantially correct.

You requested me to measure item e again.

I have done so and the dimensions e are variable with respect to weather conditions. What might happen is that on the blue print and on the original laying out of the drawing the dimensions might have been what Mr. Darby said they were in his question, they are not permanent measurements as would obtain in structural material, but they vary with weather conditions and temperature and atmosphere and pressure, and so forth.

The figures which I have checked up are that e is 2¾ inches as measured by my direction some weeks ago or over two months ago and as measured through the variable climatic condition we have had here in the last three or four days it will come from 2¾ inches to above 1/32 of an inch more than that shown, 2¾ to 25/32. I will call it 13/16. From 2¾ to 2 13/16.

e for the large cone varied as I again made the measurements in the last few days from 4 to 4⅛ inches.

The measurements on this chart were measurements made by me and drawn under my direction. I actually made the measurements myself.

PLAINTIFF'S REBUTTAL PROOFS.

CLAIR FARRAND.

CLAIR FARRAND, called as a witness in rebuttal, on behalf of the plaintiff, having been first duly sworn, testified as follows:

DIRECT EXAMINATION BY MR. DAVIS:

I am a manufacturer of radio devices. I am president of the Farrand Manufacturing Company and also president of the United Research Corporation.

The Farrand Manufacturing Company is a licensee of the plaintiff here.

As to how long I have been manufacturing loud speakers using this cone of the patent, that is licensed under the patent, I first started in 1921 and continued in 1924.

The device that I manufactured in 1921 was a single cone. It was driven by so-called dynamic drive. It was sold on the market under the name of Phonotron.

The sale of that was discontinued and afterwards the Farrand Manufacturing Company organized and began again to manufacture these loud speakers in 1924.

This Phonotron was the first radio loud speaker manufactured under the Hopkins patent as distinguished from phonographs.

I have been connected with the Farrand Manufacturing Company as president since its inception. My duties include engineering.

I organized an engineering and research laboratory in that company and conducted investigations in acoustical and loud speaker problems. The engineering of the company has been done under my direction.

I have been manufacturing and selling these loud speakers of the cone type in competition with other manufacturers from the beginning of the manufacture of radio loud speakers of that type.

I have been familiar with the loud speakers manufactured by the Radio Corporation since it began manufacturing cone loud speakers.

That company has manufactured and sold the Radiola 100, the Radiola 104 and the Radiola 100-A and the Radiola 106. The Radiola 104 I believe was the first.

The Radiola 104 had a cone, the basal diameter of which was approximately 6 to 6½ inches. The rim was approximately half an inch in width.

The Radiola 100 had a cone very nearly 10 inches in diameter with a rim of approximately the same width, that is, ½ inch.

The Radiola 100-A was a smaller cone, I believe, about 8½ inches in diameter with about ⅝ inch width rim.

The Radiola 106 is the most recent of the Radio Corporation speakers and employs the dynamic drive as did the one other Radiola 104, this Radiola 106 has a cone with a basal diameter—I measured that and could I consult my notes on the measurement? It is eight inches and the over-all diameter of the tympanum including the rim was 8⅞ inches.

The rim was made of kid leather. The Radiola 100-A has been made with paper rim, one piece with the body of the cone. The Radiola 100-A used a paper rim in one piece with the body of the cone. The rim itself was serrated and cemented to a paper ring which was in turn fastened to the frame.

I have been familiar with the loud speakers put out by the Victor Talking Machine Company since they started putting out cone loud speakers.

The first type of loud speaker I am familiar with, the Victor Talking Machine Company, marketed, was one employing a Lumiere diaphragm and that is a pleated paper diaphragm made of a piece of paper of rectangular shape and folded and then formed round in a disc shape.

The loud speaker has two of these diaphragms in it, to one of which the actuating motor was applied and the other on the opposite side merely acted as a screen to enclose the device.

In that commercial loud speaker, the diaphragm, was of the same general construction although not the same size as Exhibit No. 16, it was much smaller.

This Lumiere type speaker stayed on the market for a year or eighteen months as I recall and then the Victor Talking Machine Company used in their phonographs or their electrical actuated phonographs and radio-receiving set combinations a conical diaphragm loud speaker built by the General Electric Company and sold to them by the Radio Corporation of America.

As a matter of fact, they used all types that I have mentioned except that I do not know whether they have as yet incorporated the Radiola 106 loud speaker as that is a quite recent addition to the Radio Corporation line.

As to how the size of the cone and the width and the material of the rim of the cone have entered into the practical problems of design which I have encountered in my experience in manufacturing these loud speakers, these are very practical items in designing a loud speaker to produce commercially in competition with other manufacturers of similar devices. This field is a highly competitive one and it is necessary to attain as good results as any one else in the same field can secure.

All these items affect the efficiency of the device and its quality of reproduction. Theoretically it should

be possible to produce a sound wave of loud-speaking volume with a very small diaphragm. This, however, has not been done practically or done in a commercial way. All of the devices that I am familiar with have been of fairly large cones. The first Radio Corporation model being the smallest.

The small cone, that is to say, a cone 3 inches in diameter, would have to be capable of a very large displacement in order to produce the same volume of sound as a larger cone at a smaller displacement.

Furthermore, to give the device a reasonable degree of efficiency so that it would be competitive, the cone must be light and it must be very stiff. Its support must permit this large axial motion. The practical difficulty encountered is that when you so construct a cone in this manner the flexible supporting rim is so loosely attached that the bell-like vibrations or deforming vibrations of the cone which have sometimes been termed parasitic vibrations, are not properly restrained and blasting or paper rattling results.

The larger size cone does not require as great an amplitude of motion and is therefore a more easy device to construct. When the size of the cone is decreased we find another difficulty encountered and that is the cone structure has a resonant period which has an annoying tendency to fall in the voice range or in the range of frequencies mostly used.

In present-day radio broadcasting reception, we deal with frequencies from 50 cycles per second to 5000 cycles per second. The lower frequencies being necessary to give the quality to the bass of the music, the higher frequencies at 5000 and as a matter of fact above 5000 (almost to seven and eight thousand) give the distinguishing quality to the sound which distinguishes a violin note from a flute of the same pitch, supplying the harmonics of the fundamental.

The fundamental period of a cone structure in the voice range gives rise to what has been termed muffing sounds which tend to render the speech inarticulate, and it sounds very much as if the words were spoken in a barrel so that an increase in size of the cone lowers this fundamental period and brings it below that point.

The fundamental period of the cone is due to two things, one is the effective mass of the entire cone structure including motor and the elasticity of the support of the cone structure. These two items are analogous to inductance and capacity respectively in an electric circuit.

The present-day cone design, and by cone design I mean the complete loud speaker, depends to a very large degree upon this resonance for the impression of bass in its response, and inasmuch as this resonance depends upon the support at the edge and the other parts of the cone structure, the response can be changed materially by proper choice of the supporting rim. The looser the support the lower will be the period of the cone structure, and the tighter the support the higher will be the period of the same cone structure.

In practically designed structures as small as 6 inches tend to have this resonance response in the voice range and it is very difficult to remove it therefrom.

When I said structures as small as 6 inches, I was referring to the basal diameter of the cone, more particularly to the Radiola 104.

If the over-all diameter of the tympanum, that is the cone plus the base were 9 inches, and the base occupied one-half the area, the base of the cone occupied one-half of the area, the diameter of the base of the cone would be 6.36 inches.

The tendency of designers in order to overcome these natural difficulties has been in the past few years, in the design of the dynamic loud speaker, to increase

the size of the cones toward the present-day range from approximately 8 inches, in some commercial models to 12 inches in diameter.

The history of these changes in size starts probably in a commercial way from the Pathe model which I believe is exhibited here which had an over-all diameter of about 8 or 9 inches, and then the next step was to cones of 17 inches in diameter, this largest size giving a more pleasing bass.

The next step was cones 36 inches inches in diameter, in this case still more pleasing bass. These structures were not enclosed in cabinets and were fragile and the public reaction against them hurt their sale.

They were actuated by a balanced armature form of so-called magnetic type driver. Not by a dynamic driver.

The public reaction called for a smaller type speaker which was made and enclosed in a wooden cabinet somewhat clock-like in appearance with a cone having a basal diameter of about 7 inches. These sizes were deficient in reproduction of lower tones and when the market swung around, so to speak, and called for a radio cabinet containing a loud speaker as a piece of furniture, sufficient size and room was available to use a larger cone so that the present-day dynamic has been designed. Most all companies use cones as I said before varying from 8 to 12 inches in diameter because sufficient space was allowed within the cabinet and improved quality reproduction resulted.

I spoke of the difficulty of keeping the resonant period out of the intended useful range in the case of the small cones. I will state more fully why it was difficult.

The small cone structure has, due to its size, a definite mass and a mass of associated air and together with the motor determines the total effective mass of the system; elasticity of support is such that within

practical limits the fundamental period of the device could not be reduced low enough to remove it from the range where it was most troublesome, that is, of 350 cycles per second. The period could have been lowered had it been feasible to sacrifice efficiency. This could have been done by increasing the mass of the structure but response would have been so lessened that the device would not have been commercial.

The elasticity of the entire system involves the elasticity of the rim itself. It is a definite factor and many manufacturers actually stretch the rim, either leather or cloth, to give uniformity to it so that reproduction could be controlled.

I do not agree with Dr. Miller that in the past years there has not been a progressive improvement in the range and also in the balance of the sounds that have been produced by these loud speakers. There has been a very definite improvement in the range and balance of sounds in the past few years. There has been an increase in the power available to drive them and the power available to drive them has increased a great deal. I imagine actually they are used at about the same intensities as they were used heretofore.

A cone speaker which existed we will say in 1913 for use on phonograph records would not be required to cover so broad a range of frequencies as the present-day devices, because the records of those days did not have the lower tones as pronounced as they now have. The most rigid requirement for reproduction is radio broadcasting of today where the tones transmitted are actually as low as 50 cycles. The present-day record is deficient in frequency between 50 and 100 cycles so that the requirements of the record reproduction are not as severe as the radio reproduction.

I have pictured how the flexibility of the rim comes into this design. I will now tell you what would have been the situation if you had no rim at all and clamped

the supporting frame or rings directly on the basal edge of the cone. If the supporting ring were clamped directly to the basal diameter of the cone on its periphery, the device would be so stiff that motion in an axial direction would be limited. This would limit the response and decrease its efficiency and raise its fundamental pitch of the sounds as reproduced, which would be much less in intensity; you would probably get some muffling in the vocal range. When I speak of raising the fundamental pitch I mean the natural resonant period of the diaphragm structure as a whole.

The conclusion from what I say is, that with a cone rigidly supported at its basal edge, the fundamental pitch would be brought up within the intended range of the cone itself, it would be much higher.

With no restraint on the edge of the cone at all, you would expect to have such a freedom that increased efficiency would result but practically the edge would lack support and the periphery of the conical portion would deform much in the same manner as a bell deforms when hit with a blow at its periphery.

This deforming vibration, a sort of a parasitic vibration, builds up and gives rise to paper rattle or blasting.

Furthermore, without the rim the sound wave, tended to be produced on one side, would circulate to the opposite side and reduce efficiency and the lower tones would not result and thirdly the lack of support of the edge of the periphery by the rim would make it a very difficult matter to keep the coil centered in the annular gap and prevent rubbing.

In dynamic speakers of this type this is a very important feature so to make the structure as small it is now and they are not particularly small and cheap, it is necessary that the clearance around the copper coil be extremely small so that the total gap through which the magnetic flux must be forced is small.

A clearance of the order of 10/1000 of an inch is ordinarily used inside of the coil and outside and if the outer edge of the cone is not supported the weight of the cone itself will so shift the coil that it will rub.

I have prepared a cone, associated it with one of the defendant's drives, made the cone of the same size as the defendant's cone and supported the cone with a paper rim instead of a cloth rim. I have it here in court.

I can demonstrate first the action of the cone with the paper rim as compared with the action of the cone with the cloth rim and then demonstrate this movement of the edge of the free cone about which you have spoken.

I have constructed a conical diaphragm with the same basal diameter approximately as the defendant's structure with a plane peripheral rim of paper. The altitude of the cone is somewhat less, more nearly one-fourth of the basal diameter. This has been mounted on a Fada dynamic motor and supporting frame.

MR. DAVIS: I offer that in evidence as Plaintiff's Exhibit 31.

(Received in evidence and marked "Plaintiff's Exhibit No. 31.")

THE WITNESS: I will compare that with the defendant's device of the larger of the two sizes.

MR. DAVIS: Let that be marked for identification.

(The same was marked "Plaintiff's Exhibit 0 for Identification.")

THE WITNESS: I have chosen this defendant's device instead of Plaintiff's Exhibit 4, because the latter did not operate as well as this one. I believe its

efficiency has been somewhat lessened by the fact that it has been taken apart and put together. This device, Exhibit O for identification, seems to operate satisfactory with a good degree of efficiency.

Both speakers are operated on a usual type amplifier supplied by a photograph record in conjunction with an electro-magnetic pick-up. The input to the two speakers will be the same in both cases. I will now play the Plaintiff's Exhibit No. 31 and now Plaintiff's Exhibit O for identification. (Demonstration.)

Playing the defendant's structure marked O in comparison with the Plaintiff's Exhibit 31, my impressions were that the volume and quality of sound were very similar. If there were any differences noted it was that the Exhibit 31, having a paper rim, gave slightly improved results. My only explanation for this is that the quality of paper was slightly different. It was a form of drawing paper readily procurable on the market, expensive and not used for commercial construction.

I have here a Fada speaker, that is, a speaker of the manufacture of the F. A. D. Andrea Company bought on the open market and having a leather supporting rim.

I have here a Fada speaker with a large-sized conical diaphragm, mounted with a plane peripheral rim of leather instead of cloth.

MR. DAVIS: It is stipulated, if the Court please, that this was bought two days ago in New York in the open market, and this is a product of the Fada Company.

MR. DARBY: But it is not before this Court under the charge of infringement.

MR. DAVIS: No, it is not.

THE COURT: The only thing this jurisdiction has is the cloth?

MR. DAVIS: Yes.

MR. DARBY: I assume, therefore, to avoid the objection of its being immaterial to any issue before this Court, I assume that the demonstration will show the baffle effect of the leather, or what the effect of the leather is as a rim.

MR. DAVIS: It will compare the cone with the leather and with the paper rim on one hand and the cloth on the other.

THE COURT: May I assume one step further, and that it is to show really what the function of the cloth rim is, and how the cloth rim operates in the alleged infringing device?

MR. DAVIS: Yes.

THE WITNESS: I will now demonstrate the device with the leather rim, comparing it with the device of the cloth rim (demonstration).

MR. DAVIS: I offer in evidence the device with the leather rim as Plaintiff's Exhibit No. 32.

(Received in evidence and marked "Plaintiff's Exhibit No. 32.")

THE COURT: Does the table act as a sounding board here at all or is the quality of what I hear the result of the exhibit itself?

THE WITNESS: I do not believe the table is affecting the quality very much.

The acoustical properties in the room are probably making some difference. I do not know how it sounds where your Honor is sitting. It is quite a long distance to there.

MR. DARBY: I assume that in any event th being a comparison test that the comparison fair.

THE COURT: That the comparison is fair, ye

(Further demonstration.)

THE WITNESS: I will play defendant's structur Exhibit O for Identification first. (Demonstration I will now compare it with Plaintiff's Exhibit No. 3 (Demonstration.) The comparison of defendant's d vice marked O is identical, with Plaintiff's Exhibit N 32, which indicates to me that the volume and quali of sound are approximately the same. If any diffe ences were noted, it was in favor of the device with t cloth rim.

THE COURT: Would you mind before goi further—Mr. Darby and Mr. Davis, will you co up here with me on the bench, so that we can he the same thing.

(Mr. Darby and Mr. Davis sat by the Court

Q. 47. Mr. Ferrand, will you lift those things while you are putting this on, or take that box awa

A. Yes. (Demonstration.)

Q. 48. Now, Mr. Ferrand, if you will substitu the cone with the paper on Plaintiff's Exhibit No. for Exhibit No. 32.

MR. DAVIS: Will you have that other one tak off the table.

A. Yes. (Demonstration.)

Q. 49. I would like to have Mr. Ferrand say wh he heard.

A. The comparison just made was first a co parison between defendant's device marked O wi the cloth rim, and the Plaintiff's Exhibit 32, with t

leather rim. We were listening at a distance of approximately thirty feet. The device with the cloth rim had more volume than the device with the leather rim. The next comparison was between the device with the cloth rim and Plaintiff's Exhibit 31 with the paper rim. The device with the paper rim appeared to have more volume than the device with the cloth rim.

Q. 50. Mr. Farrand, will you just for a moment have these devices, any one of them or any two of them, driven at a greater volume just to give some idea of what volume it will stand without blasting. But make it short if you will, because it is not very pleasant.

A. (Demonstration.)

Q. 51. Now, put that on the leather rim for a minute, the same volume.

A. (Demonstration.)

Q. 52. Would you mind making the same comparison with the paper one?

A. (Demonstration.)

MR. DARBY: Does your Honor hear the rattling in the last one? I do not want to be presumptuous while you are conducting the test, Mr. Davis.

MR. DAVIS: Go ahead.

MR. DARBY: I would like while we have the paper and the standard Fada, I would like to have the Court hear the sound of those two so that we will not have to reproduce the experiment at another time.

By MR. DAVIS:

Q. 53. Now, Mr. Farrand, will you please take the defendant's device marked for identification——

THE COURT: May Mr. Darby tell you what the purpose of hearing at a closer distance was?

MR. DARBY: Yes. I heard a hissing sound quite comparable to a needle scratch in the standard Fada which I did not hear in the paper rim structure and I intend to ask Mr. Farrand something in cross-examination about that subject unless you want to do so first.

By MR. DAVIS:

Q. 54. Did you hear it, Mr. Farrand?

A. No. I would like to try it again and get that out. I did hear a slight rattle in the white paper model at the extremely loud volume, and if you will observe the structure itself you will see that in making it out of the Fada device that the leg supports touch the cone in spots when it moves to an extreme excursion and this rattle can be stopped by depressing the paper there and keeping it away from the leg supports. I would like to listen to the needle scratch that Mr. Darby speaks of. (Demonstration.)

Q. 55. Did you hear that noise that Mr. Darby refers to?

A. It seemed that the Fada speaker with the cloth rim was slightly more efficient in extremely high frequencies than the exhibit with the paper rim. I would assume that this is due to the difference in texture of the paper.

Q. 56. And the increased audibility of the sibilant sounds that Mr. Darby was referring to is due to the higher efficiency at high frequencies, is that right?

A. That is correct.

Q. 57. That is, these sibilant sounds of the human voice and of the needle scratch are of very high frequencies?

A. Yes, above 3500 cycles.

By THE COURT:

Q. 58. Which was the more efficient, did you say?

A. The Fada structure with the cloth rim, that

was more efficient at the higher frequencies above 3500 cycles.

MR. DAVIS: We all heard the same thing.

MR. DARBY: That is what I had in mind. My understanding was that that was a greater efficiency at that frequency.

THE WITNESS: I want to demonstrate in a visible way the movement of the Fada cone as it vibrates in response to the music from the phonograph and also to demonstrate the weaving and other movements of a Fada cone without any rim when subjected to the same music and in order to make the demonstration clear I may say these movements are not easily visible to the eye.

The movements of the cone while at the lower frequencies are extremely large, that is, in some cases plus or minus one-sixteenth of an inch, but they are not easily visible to the eye. I might explain that at the higher frequencies the motions are much smaller and at 5000 cycles may be less than one-thousandth of an inch.

At 100 or 50 cycles the motions will be as large as one-sixteenth of an inch.

Those frequencies are not visible because they are too rapid and in order to view them distinctly and see what the phenomenon is, a stroboscope light is often used and I will demonstrate this in court.

The stroboscope light consists of a source of powerful light from a lamp, a revolving shutter which is made in the form of a disc with a hole revolved by a motor at high speed, giving a periodic illumination to the device from the light beam.

The periodicity of this illumination is made nearly that of the period of vibration of the device, so that the apparent motion is a difference of these two peri-

odicities. When they are made the same the device appears to stand still, and when the period of the light differs by, we will say, one per second, from the period of vibration of the device, the device will appear to move with one vibration per second. Where I said the device is standing still, I meant it appears to be standing still. With that explanation, I will proceed with the demonstration.

In this test a beat oscillator is substituted for the record and electromagnetic pick-up to supply a pure tone of constant frequency so that the action of the device producing a simple note can be observed. I think your Honor should view them closer. (Demonstration.) This is a simple pure note.

I have here a Fada loud speaker of the smaller size from which I have removed the cloth rim and the supporting frame, leaving the cone mounted directly on the coil support.

MR. DAVIS: May that be marked for identification.

(The same was marked "Plaintiff's Exhibit P for Identification.")

I will operate this at a frequency of approximately 120 cycles per second (demonstration). It will be noticed that at certain frequencies, many frequencies within a short range or throughout the range (demonstration), the periphery of the cone being unsupported, deforms and waves are observed to exist. They are evidenced by nodes spaced around the periphery of the cone, and at this particular frequency there is approximately 16 nodes interspaced between 16 loops of motion.

This latter condition on the 120 cycles, I mention, shows 8 loops and 8 nodes, and when the same frequency and intensity is applied to Plaintiff's Exhibit

marked O for identification, with the cloth rim, the latter gives a simple, pure tone without any evidence of blasting. The free edge cone shows apparently that the paper is being stressed beyond its limit.

As to what it is that is keeping the cone in the device marked O for identification from doing the same rattling that the device marked P for identification does, the rattling in device P for identification is caused by the periphery of the cone deforming; there is nothing in that case to restrain it, whereas, in the device which has the cloth rim, it is held in circular form, preventing deformation of the periphery of the cone and the building up of this parasitic vibration.

We will now observe these two speakers under the stroboscope light (demonstration). I have adjusted the speed of the light, together with the frequency, so that they differ slightly, and the motion of the cone of the Exhibit O can be plainly seen. That motion is a bodily motion, substantially a bodily motion, due to the fact that the frequency of 120 cycles does not set up standing waves in a diaphragm of this size.

The cone in this case is moving approximately a thirty-second of an inch.

There are undoubtedly circumferential waves present in the cone, but they are so restrained that the paper is not being stressed beyond its elastic limit, and no blasting occurs in this device, as it does with the free edge cone. There you can adjust the volume on the free edge cone and you can actually see at low volume the deformation of the periphery and the building up of the circular vibrations, and finally the vibration goes up so that blasting occurs at a reasonably low volume. (End of demonstration.)

I heard Dr. Miller's statement yesterday to the effect that in his opinion a sound box was a baffle. I cannot see by what line of reasoning a sound box may be termed a baffle. The purpose of a sound box is en-

tirely different from the purpose of a baffle. The sound box encloses one side of a small diaphragm, with the exception of a small area at its center. The distance of the walls of the sound box from the diaphragm is in some cases less than one-tenth of an inch. The purpose of it is to highly compress the air in this chamber so that the high pressure wave will be applied to the throat of the horn which is placed over the small opening in the sound box. The dimensions of the sound box are extremely small. One thinking of a baffle thinks of something larger and entirely different. The purpose of a baffle, on the other hand, is to separate the action of the two sides of a diaphragm in free air, operating directly on the air to produce sound waves, and not as in the case of a sound box through a transformation device like the horn.

The baffle, as I said, separates the action of the two sides of the diaphragm allowing the waves, to form on either side, and then meet and ultimately form a wave of substantial volume.

The dimensions of the baffle to function at a given frequency should be an appreciable fraction of a wave length in air of that particular frequency. Fifty cycles is extremely low frequency, and would have a wave length of slightly more than twenty feet. The wave length of a note of 100 cycles is slightly more than ten feet, about eleven feet.

In the sound box the air is confined within the sound box and compresses and moves in a direction radially towards the center of the diaphragm, applying the motion at the base of the horn.

A baffle is a device which is applicable only when you are impressing the sound on free air.

I have spoken about the purpose of the baffle to prevent the action on one side of the diaphragm from interfering with the action on the other side. I will state that a little more fully and then demonstrate it.

The diaphragm, we will say, similar to those we have in court in conical form, when moved in an axial direction, compresses air on one side and rarefies it on the opposite side; these two actions will tend to produce independent sound waves. It is apparent that they are being formed in opposite sense, and if in their early stages of formation are permitted to mingle, will cancel each other, but if the waves are permitted to form independently, so that they have been released, so to speak, from their radiating surface, and then combine, they will combine to a resultant sound wave of appreciable amplitude. The effect of the baffle is to permit them to form and separate from the radiating surface without cancellation. The effect of the baffle is to permit them to extend further from the source and form more completely before they intermingle, the baffle being placed around the periphery of the diaphragm and extending in some cases several feet, so that the wave on one side has the opportunity of expanding several feet before it intermingles with the wave on the opposite side of the diaphragm.

As to whether or not this interference of the waves on the back and the front of the diaphragm is affected by the frequency, at the higher frequencies, the dimension of the diaphragm itself generally serves sufficiently to prevent intermingling of those two waves, and in that way act as a baffle. As the frequency is lowered, the wave lengths become longer, and the need of a baffle arises. At low frequencies of the order of 100 cycles, that is, an 11-foot wave of air with a diaphragm, 1 foot in diameter, or 9 inches in diameter, it is greatly influenced by the addition of the baffle; that is, the intensity of the sound of frequency may be increased as much as 50 per cent.

I can demonstrate this effect of cancellation of the waves with the small diaphragm. I have a small diaphragm, 2½ inches in diameter, basal diameter of the

cone. It is mounted on a standard Peerless unit motor and I will demonstrate it.

MR. DAVIS: I offer in evidence the device produced by the witness as Plaintiff's Exhibit No. 33.

(Received in evidence and marked "Plaintiff's Exhibit No. 33.")

THE WITNESS: Will you put on the same record that we used in another test, the same intensity as we have, marked with the pencil mark? (Demonstration.)

This device, Plaintiff's Exhibit 33, was operated from a phonograph record at the same intensity; that is the same amount of power from the amplifier from a phonograph record as has been used in the previous comparison. The response is not nearly as strong. It is particularly deficient in the lower tones. The deficiency in response is probably due somewhat to the motor being slightly less efficient than the dynamic motor of the Fada structure, but this motor is quite efficient throughout its range. The deficiency in the lower tones is obviously due to the size of the diaphragm itself. I said it is obviously due to the size of the diaphragm. I will explain that a little bit and tell what it is that caused the low tones to be lacking in that demonstration.

The device reproduces the higher tones which you can practically hear, the lower tones neutralizing themselves, that is, they just do not form. The diaphragm of that size producing a lower tone of one or two hundred cycles does not get a chance to form the sound wave because the opposite side of the diaphragm is doing just as much work in the opposite direction as the front side.

By The Court:

Q. 84. I miss why that is not true of all notes at all wave lengths.

A. The higher frequencies, a frequency of 5000 cycles per second, the wave length is so short—the wave length at 5000 cycles per second is one-fifth of a foot. The exact ratio is the velocity of sound divided by the frequency, the velocity of sound being 1120 feet per second divided by 5000, and if my mathematics are correct, it is approximately one-fifth of a foot or two and a half inches.

The circulation occurs at slightly less than half a wave length, so that as your baffle approaches one-quarter wave length it becomes very effective. That means that a diaphragm of an inch or so in diameter at 5000 cycles is quite effectively baffled.

Mr. Darby: Mr. Davis and I have discussed the possibility of avoiding repeating some of these experiments at a later time and I can ask one or two questions at the time the experiment was made.

Cross-Examination.

As you increase the size of this baffle without varying the size of the cone you would get more efficient results with respect to the low wave lengths. The baffle would help the lower tone.

The exact diameter of the cone is two and a half inches. It has a supporting rim of soft leather about one inch in radial width. The baffle extends beyond the edge of the leather, about one-quarter of an inch. I would not call that a baffle, however. That was a ring support to hold the leather.

XQ. 91. Will you please operate that device at the power that you had on it during the demonstration and gradually increase the power?

A. (Demonstration.)

THE WITNESS: If you increase the driving power your volume increases, but the quality does not change. However, the device of this character is so inefficient that it is not what I would consider from my experience in loud speakers, and designing them to be a commercial structure, due to the fact that you lose the low tones as I have demonstrated, as well as due to the low efficiency of the device so that it could not compete with other structures, the manufacturer could not, selling a device as inefficient as this.

Inefficient in respect to the production of sound.

Its inefficiency lies in its lack of volume. The device itself does not have the volume that commercial models on the market have at the same input.

With the driving power available for a radio loud speaker, you can increase the volume within limits.

Merely increasing the volume would not change the quality up to a certain point. Carrying the volume still further the device rattles.

If you increase the volume and the quality remains the same and the volume has not been increased to the point where it rattles, the inefficiency of the device is in itself the lessened response at all frequencies and particularly at the lower frequencies.

The reason that it does not properly respond to low frequencies, that is, its effect on your ear, is partly caused by the long wave lengths of the low frequencies mainly on the front and the back of the device.

It is also caused by the size of the diaphragm itself, not being an efficient radiator of any frequencies excepting extremely high frequencies in the neighborhood of four or five thousand cycles.

The particular difficulty of these particular long wave lengths, the difficulty of the intermingling on the front and rear side of the diaphragm can be overcome by a baffle.

The small diaphragm cannot be made to produce the lower tones with the efficiency of a larger diaphragm.

In a radio reproducing device the diaphragm can only reproduce sounds which have been transmitted or transformed from the air by a relatively small microphone.

DIRECT EXAMINATION (Resumed).

Mr. Darby asked me about the power available in modern radio. I used the word "but" and then he interrupted me. I have something to say about that.

The thought I had in mind was that while there is practically unlimited power available on the modern radio receiving set, the efficiency of the loud speaker is a very important item because it affects the ultimate operation of the receiver as the response on the inefficient loud speaker is much less than on the efficient loud speaker and it is not an easy item to sell. The dealers themselves make competitive demonstrations and an inefficient loud speaker is a very difficult item to sell.

I saw these sand patterns which were put in evidence yesterday.

In the demonstration under the stroboscope I testified that there appeared on the Fada cone these radial nodes evidencing the existence of circumferential waves.

When these Fada cones are used or any paper cone of that type is used for the reproduction of music or the voice, when the device is operated at a high frequency, the radial waves set up circular nodes. As the frequency is lowered the circular nodes finally disappear. I can best explain this by referring to a chart I have.

The chart Fig. 1 represents the waves in a cone diaphragm. Assuming the velocity of propagation in

the cone of 200 feet per second, which is of the order of propagation in cone structures, and I determined this by actual experiment, I have drawn a wave of fifty cycles which is a long flat wave. In the same scale I have drawn waves at 5000 cycles.

The conical structure is represented with the vibration applied in an axial direction. The outline or contour of the cone itself is shown and it will assume a shape at fifty cycles which is practically a straight line, and the cone will appear to move at fifty cycles practically as a plunger. This is due to the fact that the dimensions of the cone are a relatively small fraction of a wave length at fifty cycles.

At the other extreme of 5000 cycles, there will, however, be many waves set up in the cone structure itself.

At frequencies between these two values, one or more or finally many waves will appear as the frequency is increased.

I will go on and discuss the waves that I referred to yesterday as parasitic waves, that is, the waves that produce radial nodes.

The waves shown in Fig. 1 are what are termed the useful wave, that is, the one most active in the production of sound and due to the vibration applied to the cone in an axial direction.

The ideal conical reproducer will be one that maintained practically plunger action at all frequencies even up to 5000 cycles. Of course, this is not feasible, the stiffness cannot be secured at reasonable mass and even probably at any mass. So that a compromise has to be resorted to.

On this second chart which is entitled Chladni figures, I have attempted to represent the actions which occur in the formation of sand patterns. These have been discussed in text books and they were described in great detail by Chladni. The left-hand column

shows a flat plate with the vibration applied in an axial direction, the upper figure being a plan view and the lower figure being a cross section. The wave progresses radially outward and is reflected from the edge, the wave progressing outwardly I have shown in a solid line and the wave reflected from the edge I have shown in a dotted line.

The wave progresses radially outward reflected at the edge, progresses radially inward, giving rise to standing waves which are evidenced by circular nodes interspaced between circular loops of motion.

The second figure is the second type of vibration of the two that a flat plate can undergo. If the plate struck at the edge or bowed with a violin bow, instead of applying the vibration axially as in Fig. 2-A, the plate will indicate the vibration shown in Fig. 2-B, that is, the vibration initiated at one side of the disc will travel in opposite directions around the disc, meet at the opposite side, and overlap and produce nodes on radial lines. These are interspaced between sector loops of motion.

Supposing that the vibration is applied at the center in Fig. 2-B, you cannot really separate these two actions in a flat plate because the material itself is not exactly uniform. It is what is termed non-isotropic.

There is always a tendency when the vibration is applied in an axial direction at the center of the disc for there to be a component of force creating a wave at the periphery much in the same manner as if the forces were applied there. That is due to the fact that the wave does not reach the edge simultaneously at all points.

You always get in a flat plate, unless extreme laboratory care is used, the two modes of vibration forming a composite of a useful and parasitic wave and

these are evidenced by a pattern consisting of circular nodes in combination with radial nodes.

In Fig. 3-A I have shown the modes of vibration of a free edge cone. These are very similar to the modes of vibration of a flat plate, the principal difference being that in giving the plate conical form its stiffness has been increased greatly without largely increasing mass.

This is a cone of the so-called Starling & Cole type. The vibration applied axially at the center travels radially outward to the edge as reflected and travels as shown by the dotted line radially inward, giving rise to circular nodes interspaced between circular loops of motion.

Fig. 3-B shows the parasitic wave which is of the same nature as the vibration of a bell. A bell when struck at its periphery undergoes a deformation, the simplest form of which is when the bell assumes a form of an elipse, we will say, with a horizontal major axis and then goes to the form of the elipse with a vertical major axis. That gives four radial nodes and is the fundamental of the bell. The particular view here is the first overtone, that is, the double frequency of the bell.

The fundamental of a bell is the lowest note to which the bell responds and is that note which gives rise to four radial nodes.

It is that note and the overtones of that note that the bell emits whenever it is struck no matter what you strike it with.

A bell always responds in that note with its overtone and depending on how it is struck the relative intensity of the fundamental pitch and the overtones vary in proportion.

The free edge cone in Fig. 3-B, the parasitic wave is very similar to that of the bell. This shows the

parasitic wave propagating circumferentially around the cone in opposite directions, overlapping, creating standing waves evidenced by radial nodes, in this figure there being eight radial nodes.

In Fig. 3-C are shown the composite of the useful and parasitic wave. If a simple paper cone is vibrated in axial direction at low volume and if it can be made of perfectly uniform material, you will get the formation of circular nodes as in Fig. 3-A. This is not possible. The parasitic wave always exists due to the non-uniformity of the material and tends to build up in amplitude. The phenomenon is of a resonant nature much in the same manner as a bell may be considered a resonant device. And at or near these resonant frequencies of the fundamental of the free edge cone, or its harmonics or overtones, the amplitude of this parasitic wave in the paper builds up to such a large extent that it stresses the paper beyond its elastic limit and the paper rattling occurs.

This is due to many factors. The thing is a resonant phenomenon and there is little restraint in the stiffness of the material in this direction to this wave propagated circumferentially, and also the resistance of the air is small, because it tends to circulate locally between a loop of positive sign, and a loop of negative sign; that is, when one sector is feeling their contents, the local section of air, it does not resist this building up of the parasitic wave; so that we have the composite of these two waves with circular and radial nodes.

In Figure 4-A, I have attempted to show what happens when a Starling & Cole cone is held by a plain peripheral rim in a ring support. I have lettered the figure the same as lettered in the Hopkins patent. The ideal condition is shown in Figure 4-A, where we have only the circular nodes. The action is the same as in

the previous figure. The vibration is applied axially; the wave is propagated radially outward to the edge as shown in the solid line, reflected at its periphery travels inwardly, as shown in the dotted line and makes waves with circular nodes. The device, however, tends to undergo the same mode of vibration, as a free edge cone, that is, the parasitic waves tend to build up because of the non-uniformity of the structure itself. The rim, however, greatly restricts the amplitude of this wave and prevents the deformation of the periphery of the cone, but does not eliminate this parasitic wave entirely, however, so that radial nodal lines will always be apparent.

So that we have in the actual device itself a tendency to produce nodal patterns similar to those shown in Figure 4-C, which are the result of the useful wave applied axially on the cone and the parasitic wave building up and traversing the cone in the circumferential direction, the useful wave producing the circular nodes, the parasitic wave producing the radial nodes. The exact number of nodal lines shown depends upon the frequency. At the higher frequencies there will be more radial nodes and more circular nodes. At lower frequencies the circular nodes may ultimately disappear, due to the fact that the cone itself is a small fraction of the wave length, as I have shown in Figure 1.

They may be said to be chased off the cone by the lengthening of the wave length.

CROSS-EXAMINATION BY MR. DARBY:

I will state concisely what conclusion I draw from that I have illustrated on the chart labeled Chladni figures; that is, what conclusion I draw that is pertinent to the issues of this case.

The conclusions I draw from this chart are that they show the effect of adding the plane peripheral

rim to a conical diaphragm restricting the parasitic wave to such a degree that the cone may be properly loaded with a useful vibration.

All of the facts that I have testified to as illustrated by the Chladni figures were not taught by Chladni, were they not?

The Chladni figures are the figures formed by sand or other granules on diaphragms, and this method is often used to analyze the motions of diaphragms, and as I have used this method in analyzing the motions of cones, I have termed these "Chaldni figures" and they show various modes of vibration of three structures; that is a flat plate, a free edge cone, and the Hopkins cone.

The radial wave is essential to the reproduction of the sounds of an orchestra. The circular node is incidental to this.

The radial node, or at least the waves incident to the formation of radial nodes, are not essential. They are not only not essential, they are detrimental.

The ideal speaker though never yet attained, would be one which would completely preclude the setting up of waves incidental to radial nodes.

The ideal speaker would preclude the circumferential waves which set up the radial nodes.

In Defendant's Exhibit No. 32, which is a sand pattern taken at 400 cycles per second, these radial nodes are quite pronounced, indicating that waves incident to radial nodes occur.

I might explain that they are always evidences in conical structures of this type, and cannot be entirely eliminated. Various methods have been used to suppress them, one of which is to corrugate the cone circularly with concentric corrugations which give it a stiffness, and tend to suppress that; that is best evidenced in the Radiola 106 which we have here.

In defendant's structure, the waves incident to radial nodes at 800 cycles per second, are likewise quite pronounced.

In this case we have evidence of the radial nodes pronounced, and also circular nodes. That is shown on Defendant's Exhibit No. 33.

The same is true with respect to Defendant's Exhibit No. 34, being the sand pattern at 1200 cycles per second. The same is true on Defendant's Exhibit No. 35, 1600 cycles per second. This is slightly less pronounced.

The same is true on Defendant's Exhibit No. 36, 3200 cycles per second. This shows the radial and circumferential nodes in a pattern which is not extremely uniform, but they appear to be about equal in intensity.

From my experience with cones and sand patterns of cones which show the figures, I do not question the accuracy of what these sand patterns illustrate in the defendant's device.

I would expect to get figures of that sort with that cone structure.

In sound reproduction in a radio loud speaker, I consider the essential frequency to be from 50 to 5000.

No cone would be of any practical utility if they did not use frequencies between 400 and 3200.

If you move a paper cone or any part of it at a sound frequency, it will create a sound wave; that is right. The particular area moved will create a sound wave. It, however, may be completely neutralized by an adjacent area moving in an opposite direction, so that while one area may be producing a sound wave, the sum of several areas may not be producing any sound whatsoever.

That is not true whether or not the wave is circumferential or whether or not it is radial.

I will explain why not. It is a little involved. The wave in a cone as initiated by the vibration applied in an axial direction and the area near the source, that is nearest the apex, is principally active in producing the sound wave. At the higher frequencies, this area is very small. At 5000 cycles it may only be an inch in diameter. As the frequency is decreased, this area becomes larger and larger until at the lower frequencies of 50 to 100 cycles it encompasses the entire cone structure itself.

Now, the area of the cone nearest its source is most active, as the waves in the air are still coupled with the generating impulse, and it is due to this particular area that the major production of the sound occurs. As the wave progresses from there on, it is an uncoupled wave; it has been released, so to speak, from the radiating surface; so that when we consider in a cone structure of this sort, I believe that the first wave in the cone nearest the apex, I mean to the wave, the one traveling outward, is principally responsible for the production of sound, and is not easily neutralized by a concentric ring, still further outmoving in the opposite direction.

However, the parasitic wave which builds up and traverses the cone in a circumferential direction is an induced wave, so to speak, and builds up slowly. It is not coupled tightly to a source of power, and the impulse generated by the various areas of paper sectors, so to speak, may more nearly neutralize each other than the circular annular areas.

Any particular frequency within the audible range has a characteristic note, a simple tone.

Taking in the desired size of diaphragm what determines the volume of sound given off by that diaphragm is the amplitude of the axial motion at the apex of the conical diaphragm.

In the electrical actuating device, such as used in radio, the amplitude increases as the frequency is lowered, for the same output of sound.

When I put 120 cycles on the cone of the Fada standard construction at a fixed volume, a fixed volume of sound, keeping the amplitude of motion of the cone the same and changing the frequency, the volume increases as the frequency is increased, and decreases as the frequency is decreased.

If you change the tone characteristic at 120 cycles, to the tone characteristic of a thousand cycles, you would expect a much greater volume. It would be very difficult, with the apparatus available, to get the same amplitude of motion at ten times the frequency.

That is due to the fact that at higher frequency an enormously greater power would be required to produce the same amplitude of vibration as you could secure at the lower frequency.

I have experimented in this field over a period of many years. My work on loud speakers started more than ten years ago.

The testimony that I gave yesterday was of course based on experiments and work that I have personally conducted.

I am a substantial stockholder in the Lektophone Corporation.

I did not take any active part in the organization of the Lektophone Corporation.

I am a member of the board of directors at the present time, but not in the first year of its incorporation. Pardon me, Mr. Darby, I believe the corporate structure was changed, but when the corporation was incorporated I had no part in it and was not a member of the board.

This is not the first year I have been on the board. I have been for several years.

The term is yearly and this is not the first year. I have been serving in that capacity about three years. I have testified on behalf of the Lektophone Corporation in numerous of its previous suits on the Hopkins patent.

Yesterday I mentioned the fact that there had been enormous improvements in power and range in radio reception and similar improvements have been made in radio transmission during the period of years from 1918 down to the present day.

I am asked what effect the angle of the cone or its altitude has on its operation.

The angle or altitude of the cone affects somewhat the balance of the speaker, that is, the proportion of high frequencies to low frequencies and is involved with the texture, stiffness, and the paper itself, and all the other associated items that go into the design including the stiffness of the rim, stiffness of other supports, mass of the motor parts, and all of these things have to be considered in the design of a speaker to blend them in about the type of reproducer you want to secure.

I agree that the angle of the cone plays an important part on the question of balance, excepting that it is not critical. It may be varied a great deal. Some designs include an angle in the cone of the concave side of the cone of 120 degrees and other designs it is 90 degrees. It is necessary to change it somewhat as the basal diameter of the cone is changed to get the best results from that given basal diameter. It is a matter of cut and try of what you are after.

There is no way of predicting exactly the thing. You get it by experience and then you can from past experience predict fairly well what you may expect to get with a given diameter cone. It is a very difficult thing. I have considered myself fortunate to be able to predict one or two items in the last ten years. I

would not attempt to do it regularly. That is based on my own personal experiments.

The angle of the cone has this effect, referring to my chart and the middle column, the angle of the cone with the vibrations imparted directly to the apex and axially of the cone has a great bearing on the rigidity of the cone or at least the over-all rigidity of the cone to the vibration. You desire stiffness in that direction, everything else being equal.

The effect of the stiffness on the operation is that it permits a larger area of air to be moved by the diaphragm. For instance, the flat plate shown on Fig. 2-A, I have shown these waves to the same scale as Fig. 3-A, but actually the plate of the same mass would not be nearly as stiff as the cone in Fig. 3-A, and the waves are much closer together and you could not impart the vibration with nearly as large an area or volume of air as you can when you increase the stiffness by giving it its conical shape.

If my theory is correct that the closest approximation to actual bodily movement is the most desirable, the stiffer the cone is the better it would be, providing you can secure the stiffness without adding to mass. That of course is a difficult thing and has to be compromised. One way of doing that with the qualifications of the compromise that I brought out, one way of increasing the stiffness within limitation is by making the altitude of the cone greater, within certain limits. There is probably a best angle for a given paper and a given amount of power. What that is I hesitate to say.

As to why in Plaintiff's Exhibit 31 I used a cone with a substantially less altitude than the cone of the Fada structure marked Plaintiff's Exhibit O for identification. The reason the cone with the less altitude was used in building the structure with the paper rim was that I was asked to build a device more nearly like

that disclosed in the Hopkins patent, but found I was not able to do so with the Fada structure, even though I had modified it somewhat, and so I had to sort of fit together, which resulted in a cone of about those dimensions.

I had not measured and I cannot tell the exact altitude of the cone, but I would say that it is less than the Fada structure and more than one-fourth of the base or basal diameter of the cone. It is perceptibly less in altitude than the Fada structure.

As to why I used a different kind of paper from the paper of the Fada structure, that device was built in Wilmington and that is the only paper we could procure in the city. As a matter of fact, however, I called up someone at the Fada factory in New York and told them that I wanted to build some structures for a demonstration or experimental purpose and asked them if they would give me some paper. Mr. D. Andrea said he would, but he could not supply it in sheets, but only cut to size for the building of the Fada cone itself, and as I wanted to build a complete cone and not necessarily the same size as the Fada, I was not able to use it. This was a day before I left for the trial and was forced to build the structure down there.

I believe Mr. Andrea is president of the Fada Company.

In this structure, Plaintiff's Exhibit 31, when an abnormal power was used you heard the paper rattling. Of course, all these cones blast, even the defendant's structure, but the one with the paper rim gave forth extraneous sounds first and that is due to the paper rim actually touching the leg support as it moves. I did hear a typical blast after you passed that point. I heard it in both devices. If you put enough power on any diaphragm type of loud speaker you can make it blast, because they are designed to carry a definite volume suitable for household reproduction and it is not

good economics to build them to carry an enormous volume.

The only real problem that blasting presents is that you do not want blasting to occur in the operation of the cone at the volume that you ordinarily use to reproduce sounds to the ear in home use and also at a larger volume. We have a practical consideration nowadays of designing speakers so that they will reproduce sufficient volume for dealer demonstrations, and this volume is many times greater than is used in the household reception.

Sibilant sounds of speech are necessary for proper reproduction. If they are omitted, the loss of sibilants gives a lisping characteristic to the speech which is not faithful reproduction. Sibilant sounds come roughly between 3000 and 6000 cycles. A good reproducer, a good radio loud speaker must be able to reproduce those frequencies faithfully.

You state that I pointed out that the illustration of Fig. 4-A would be the ideal condition in my opinion. If I did, I might say now that it is not quite the ideal, because there is the still further ideal to have the device move as a plunger entirely. This Fig. 4-A shows the existence of circular nodes.

As a matter of fact, however, in actual practice the cones employed as radio loud speakers do not even come up to the illustration of Fig. 4-A. That is a portrayal of one mode of vibration of the Hopkins cone. The Hopkins cone operates that way partly. That is one of its modes of vibration.

The chart does not entirely portray the operation of what I call the Hopkins cone. Fig. 4-C outlines both modes of vibration and theoretically portrays the operation at one particular frequency.

I know of no commercial structure built like the cone diaphragm illustrated only in the drawings of the Hopkins patent.

I refer to my having marketed a cone structure which is oval in shape and which had a circumferential corrugation.

I might add a little bit to my previous answer, Mr. Darby, in order to make the matter perfectly clear. I also recall the Radio Corporation marketing a device with a cone practically identical with the figure of the Hopkins patent excepting that that cone did have in the cone itself some circular corrugations. The type number of that Radio Corporation model was 100-A. The cone 100-A of the Radio Corporation had a castellated edge. I described that yesterday. That is, in order to form it, in forming your cone out of one piece, the edge tends to stretch and a steaming operation is required and it is a simple matter to castellate the edge of the paper so as to have a periphery portion having minute slits in it. The cone of the Radio Corporation 100-A was slightly under nine inches in diameter.

As to whether or not I know of any commercial loud speaker put out by anyone with a diameter of nine inches or more that was made exactly like the cone illustrated in the drawing of the Hopkins patent in suit. I would say that the 100-A is the nearest one to what you are describing, and the diameter of the entire tympanum or diaphragm itself was, my recollection is, a little less than nine inches in diameter. That is my recollection. The overall diameter inside of the ring is very close to nine inches.

The Radio Corporation is still making a model which is very close to the 100-A. I do not know the new type number but practically that. I believe practically the same structure. As a matter of fact, my recollection is that the cone structure of this 106 that we have here is the same cone structure that they are now making as the 100-A or its successor. They have since changed to leather at the edge.

XQ. 203. And this cone structure is corrugated right throughout?

A. Yes.

MR. DAVIS: Referring to the Radiola 106?

THE WITNESS: Yes. The cone structure is corrugated with circular corrugations throughout. My recollection is that the 100-A had those same corrugations?

In that respect it was different from the structure shown in the Hopkins patent. The effect of those corrugations is that they tend to stiffen the device and tend to suppress that portion of the parasitic wave which remains in the cone itself. The rim largely restrains them and the circular corrugations restrain them still further.

My best recollection is that the diaphragm of the Radio Corporation of 100-A plus the rim was nearly nine inches. I believe it was slightly under nine inches. I testified to that before in some other suit, but I do not recall the exact figure.

With the exception then of the Radio 100-A type, about which there is some indecision as to the exact over-all size, I do not know of any commercial loud speaker of nine inches or more over-all diameter of the cone and rim that was marketed employing a cone exactly as that shown in the Hopkins drawing of the patent in suit.

With reference to a corrugation at the annular rim in a structure that I put out myself, that was not the first type of loud speaker that I manufactured. The first type of loud speaker I manufactured myself used the diaphragm about 12 inches in diameter and had one corrugation at its edge. That was marketed in 1921, the larger size I just referred to, that is the elliptical shape, was marketed in 1926.

I did not testify in the suit of Lektophone against the Western Electric Company. Prior to the com-

mencement of that suit I wrote an article for one of the radio magazines on loud speakers. It was a paper which was delivered before the Radio Club of America on cone loud speakers. That was before I was familiar with what evidence had been put in in the Western Electric suit. It was published in the *Radio Broadcast*, a radio magazine. This paper illustrates both photographically and diagrammatically the structure of the cone which I have referred to as having made and marketed.

XQ. 224. And will you kindly point out the corrugation in the peripheral edge that you referred to?

A. The peripheral edge is the extension of the cone proper in the form of a semi-circular gutter beyond which extends the flat portion clamped in the rings.

In other cases that I have testified in for the Lektophone Corporation I have not been questioned about this paper of mine in the *Radio Broadcast*.

I stated in this paper:

> "In the development of the telephone it became evident that it would be desirous to have the surface of the diaphragm move integrally from its center to its edge, so a diaphragm of conical shape was resorted to.
>
> "The conical shape gives extreme rigidity to axial motion and provides a surface which moves as a plunger, and which is of small weight. Cone diaphragms were used in telephones and were sometimes used in connection with horns as loud speakers. The action of the diaphragm of a plunger was to change the volume of the air in the sound-box and force a high amplitude sound wave from the orifice into the horn, while the old style diaphragm changed the volume of air in the sound-box by flexing. The usual difficulties of sound-box resonance were present, and the addition of the horn added certain resonant periods."

I was referring to the loud speaker marketed by the R. A. Thompson Manufacturing Company of Jersey City and the S. G. Brown, Limited, of London. Both of them employed conical diaphragms in conjunction with sound-boxes and horns and were used in radio receivers. They consisted of a conical diaphragm sound-box and a horn attached to that and were marketed for use in connection with a radio-receiving set.

The S. G. Brown Company, Ltd., is a British concern. It is the same Brown who was an English patentee in some of the patents in the prior art in suit.

I am asked to look at the cone shown in the patent to William H. Davis and F. E. Joss, No. 1,312,958, patented August 12, 1919, and confine myself to the cone structure itself, and tell what difference if any exists in the cone structure there shown and in the cone structure of yours illustrated in your paper. They are very similar. As a matter of fact, I believe they are the same shape. They are substantially identical.

MR. DARBY: I ask to have the Davis & Joss Patent No. 1,312,958 put in evidence.

(Received in evidence and marked "Defendant's Exhibit No. 40.")

As a director of the Lektophone Company I keep familiar with the activities of the Lektophone Company and its associated companies in a moderate way. I have no official capacity. I am familiar with the fact that the Lektophone Company has made arrangements with respect to foreign countries, the patents in foreign countries on the Hopkins invention. I am likewise familiar with the fact that the Lektophone Corporation or its foreign associate engaged in some litigation in England. I know that a suit was brought against the S. G. Brown Company, Ltd., of England.

MR. DAVIS: I may say that the patent has been litigated in England and also in France, and I have at home copies of the decisions in both cases. In England the validity was sustained but it was held to be limited to phonographs.

THE COURT: That is the Hopkins patent.

MR. DAVIS: The Hopkins patent. In this country Hopkins took out two patents, 527 and 529, and in England there was but one patent.

THE COURT: Corresponding to the 529 only?

MR. DAVIS: It was filed in England before 529 was divided out from 527 and that thing was held in England to be confined to a phonograph. In France the case went up and the patent was held to be valid and infringed and it went up to the Court of Cassation which affirmed. The same references, Lumiere, Stroh, Starling & Cole, were before both of those courts.

MR. DARBY: My understanding is, and if Mr. Davis will merely supplement the statement with one or two more facts, it will serve my purpose just as well.

MR. DAVIS: You go ahead and I will supplement it.

MR. DARBY: The Brown cone charged to be an infringement in England was eleven inches in diameter and I have not got, but I can obtain a copy of the British patent which I would like to offer in evidence without comment for use in argument with regard to the subject matter claimed in the British patent——

MR. DAVIS: If Mr. Darby has a copy of it he certainly—I have no objection to its being put in evidence.

MR. DARBY: All I wanted to get in was the subject matter of the claims in the British patent.

MR. DAVIS: Suppose we submit here for your Honor's perusal if you care to peruse them all of these decisions in the foreign courts so that they will be on file here.

MR. DARBY: I have not any objection to that.

THE COURT: Then anything that I have resort to should be available to any Appellate Court. Could we do that without putting it in evidence?

MR. DARBY: Surely.

THE COURT: Can we do this—they are not available now—but either party may have the privilege of putting the foreign patents in evidence at this time. Of course, the opinions may be resorted to without being put in evidence.

MR. DARBY: If Mr. Davis is going to supply your Honor with copies of the opinion, I have been unable to get completed opinions of the two cases in time, my time was rather limited in preparing for this trial, but my understanding is that the claims of the British patent are spread out in the opinion of the Court, and so if Mr. Davis will allow you to have that, that ends it so far as I am concerned.

THE COURT: All right, then the opinions will be made available.

MR. DAVIS: Yes.

MR. DARBY: I think it should also appear that the cone of Brown that was charged with infringement had a paper rim.

THE WITNESS: As to whether or not, in a cone structure made with a paper rim such as Plaintiff's Exhibit 31, that the paper rim gives off sound waves, I

believe that any body by vibrating, if the body is capable of reflecting sound waves, will give off sound waves and paper is no exception to that. The paper in that particular device, Plaintiff's Exhibit 31, contributes in a very small degree to the production of sound and at the higher frequencies contributes much less. I stated in my paper "In the Development of the Cone Loud Speaker" (and there I was referring to my own work in that line):

> "In the development of the cone loud speaker, many different types of construction were tried. Various materials, including hard rubber, celluloid, wood, metals, paper, etc., were tried for the cone. A fibrous paper, not highly calendered, operates satisfactorily, and presents a good commercial solution. The thickness of the paper should be approximately one mill (.001") for each inch of diameter, providing a soft finish paper is used; the thickness should be less if the paper is hard finish. The harder the finish of the paper, the greater will be found the tendency to depart from the cone shape, and undue stress will be set up in the paper, which will give rise to rattles, due to 'tin-can' actions."

As to what I meant by "tin-can actions," this was described before a semi-technical body and tried to put in as plain language as possible. The tin-can action is caused when you form a cone out of very thin paper, the atmosphere affects it and flat spots occur in a cone where the paper is not curved but flat, and when the vibrations are imparted to the cone, these flat spots rattle much in the same manner that the bottom of a tin can will rattle.

Then my paper stated: "The freedom of movement, of course is hindered somewhat by the flexing of the paper at the edge. This flexing involves a loss of power which can be compared to hysteretic losses."

I was referring to the cone in figure 1 of the article. That, is a cone provided with the rim portion clamped between the rings.

All these structures supported at the edge lose a small amount of power in moving the material at the edge in its flexing. This I said can be compared with hysteretic losses.

Hysteretic losses are taken from the electrical art where magnetic flux is changed in a piece of steel, and in changing the flux in the steel a certain loss of power occurs which is termed a hysteretic loss, the analogy being that in moving paper, changing its shape by flexing it, you lose power in changing it. That is true in flexing any body, springs, for instance, there is a loss of power in the spring called the hysteretic loss.

My paper continues:

> "Experiments were conducted to determine the amount of these losses and to lessen them. Sandpapering an annular portion at the edge of the cone, or substituting light flexible paper or other material, and castellating the paper edge, were tried. Where heavy paper was used, the above experiments improved the results, and were manifested by an increased clarity of treble. Complete freedom of the edge was obtained by suspension of the cone on silk thread. The photograph at the top of page 514 is of the free cone device. The cone was mounted on a paper straw, and reinforced by silk threads from the straw to its periphery. On one end of the straw was mounted a bobbin which floated in the annular field produced by the electro-magnet. The complete assembly was supported by threads. There was nothing to retard the axial motion of the bobbin; it floated freely in the sound wave, and motions as large as ⅛th of an inch were sometimes noticed when used."

That device was used as a microphone and not particularly good as a loud speaker at higher powers, the one-eighth inch motion was not the motion when used as a loud speaker. That was a motion that was observed when the "H" sound the "huh" expression, the first impulse of the breath would move the cone one-eighth of an inch. The device operated as a loud speaker, however, but not at any such output as would be undergone by one-eighth inch motion of the cone because paper rattles, deformation of the cone would result and blasting occurs.

It was with respect to the cone suspended by silk thread that I was referring. The one having no rim support for the cone structure.

In other words, I found that with the hinge structure, it was desirable to make more flexible the motion of the cone, to obtain the particular type of reproduction you wanted in that particular structure. Other structures you would not have to sandpaper the edge of the cone because the paper might be sufficiently flexible.

There are two types stated in my paper, one in which the edge is castellated and that was particularly flexible not to be improved by sandpapering the edge. The other type which was pressed out of steamed paper in one piece was improved particularly when used in conjunction with a moving coil, so-called dynamic type of loud speaker motor. It, however, was not improved when used in conjunction with the magnetic type motor.

You call my attention to the fact that this statement which I am reading over again did not refer to the castellated type. "The freedom of movement, of course, is hindered somewhat by the flexing of the paper at the edge. This flexing involves a loss of power which can be compared to histeretic losses."

Immediately thereafter, I state, "Experiments were conducted to determine the amount of these losses and to lessen them."

That refers to the cone structure described in the whole article and illustrated in Figures 1 and 3 and described in the paper. I describe castellated structures in the article, too, a paragraph later.

A device may be stiff but may not have a great deal more hysteretic loss. You sandpaper the edge and you can reduce the stiffness, and the reduced stiffness may permit the cone to move a larger amplitude of motion and hysteretic loss may be the same as the device with a stiffer edge moving a lesser motion, so that it depends largely on how you are using this device. If you are using it on a motor which has the characteristic that tends to move it to the larger amplitude, your hysteretic losses may stay constant. If the motor is a motor of some fixed amplitude, the hysteretic losses would be lessened by the sandpapering.

Having pointed out that with the floating free edge diaphragm motions as large as one-eighth of an inch were sometimes noticed when used, I stated as follows:

> "As this was done, it was found that the edge of the cone, due to the slowness of curvature, was not inclined to move integrally with the rest of the cone. This was overcome by making a circular trough-like portion at the edge, which reinforced it, and retained the circular form of the cone. A method nearly as effective is to reverse a small portion of the cone at the edge, making a V-shape trough instead of the circular trough."

The Pathe loud speaker which is in evidence as Defendant's Exhibit No. 20 is an illustration of the V-shaped trough.

Then my article goes on:

"The advantages of freeing the edge of the cone are so slight that operation can be equalled by suitable proportion, while the mechanical advantage of a supporting ring at the edge of the paper are apparent. The outer portion of the cone can be conveniently turned inward and the mass of the supporting rings and its supports materially reduced without affecting its operation."

As to whether or not I considered that in some respects a free edge cone had advantages over a cone held by rings, and that the only advantage that I acknowledged at that time in October, 1926, or eight months previous to that time, was purely a mechanical construction, an advantage in employing rings; and so stated it in that article, my answer is: the article was discussing a structure of a free edge type used as both a microphone and a loud speaker. Now, a free edge device had certain advantages of sensitivity, that is, at low amplitudes, very small amplitudes, it moved more easily without restraint than the bound edge type. However, the bound edge type had mechanical advantages of support and was capable of larger amplitude of motion and greater sound operation.

MR. DARBY: I move to strike out the answer as not responsive.

THE COURT: Motion granted. Recess until 2 o'clock.

THE WITNESS: During the recess I have looked over that portion of the article to which the question was directed, and in answer——

XQ. 259. I have not asked any question yet except that. Have you had an opportunity to review the article since the noon recess?

A. Yes.

Just before the heading of "The Requirements of a Good Horn," at the beginning of the article, appears this statement:

> "In the development of the telephone it became evident that it would be desirous to have the surface of the diaphragm move integrally from its center to its edge, so a diaphragm of conical shape was resorted to."
>
> "The conical shape gives extreme rigidity to axial motion and provides a surface which moves as a plunger, and which is of small weight."

Now, I used the term "plunger" there to indicate bodily movement without flexure.

The statement continues:

> "Cone diaphragms were used in telephones and were sometimes used in connection with horns as loud speakers."

I meant in connection with radio apparatus.

The statement continues:

> "The action of the diaphragm of a plunger was to change the volume of the air in the sound box and force a high amplitude sound wave from the orifice into the horn, while the old style diaphragm changed the volume of air in the sound box by flexing."

I meant by that statement that in the conical diaphragm I had a plunger bodily movement as distinguished from flexual movement of the diaphragm, that is, flexual movement of a flat diaphragm.

In the third paragraph following appears this statement:

> "Hopkins made a large step in this direction by evolving a practical conical diaphragm of suffi

cient size to produce a sound wave of magnitude comparable to the original sound, without the use of a horn. This was successfully used with a phonograph. Large diaphragms of this character will produce a sound wave of magnitude of a normal speaking voice with a small amplitude of motion. To produce the same magnitude of sound with a small diaphragm and horn requires a much larger amplitude of motion and higher amplitude sound wave in the sound box. This high amplitude sound wave is passed out through the narrow neck-like opening of the horn and expanded along its walls and, as the area constantly increases, the amplitude of the wave decreases and ultimately passes to free air at approximately the same amplitude as the wave produced by the large diaphragm."

I meant by that statement that I could get the same volume of sound with the smaller diaphragm and horn by employing greater amplitude of movement of the cone.

I agree with Dr. Miller that in operation, in normal operation, as a loud speaker, the Fada diaphragm in reproducing transmitted speech or musical program, operates throughout its entire conical portion.

It vibrates throughout its entire conical portion, but I have already described what I consider to be the areas which were active in producing the sound operation.

Taking the note characteristic to any particular frequency, let us say, 2786, as to whether or not that note, or the vibrating portion of the diaphragm is going to be confined to any particular spot on the paper, or is apt to be caused by vibration at any portion of the paper cone, my answer is: The note of a frequency of 2786 would be generated principally by the central portion of the conical structure; but incidental thereto

would be wave motions due to both the radial wave and the parasitic wave.

They would give off sound to a lesser degree.

As to whether I do or do not agree with the statement that any portion of the paper cone will give off any note of the range of audibility reproduced by the cone in operation, my answer is, at some frequencies I imagine a certain portion of the cone, that is, at the higher frequencies, may be standing still; this is evidenced by some of the nodal lines. At lower frequencies the nodal lines probably mean that there is no relative motion in a cone, but the entire nodal line may be moving with the cone bodily, so I can not really agree with the general statement.

XQ. 269. Then you disagree with the statement that any particular note given in use, is actually given off throughout the entire height of the altitude of the cone?

A. As I understand your question it was that any portion of the cone would generate the sound. My answer is that I believe some portions may be inactive in producing sound.

XQ. 270. And you referred, as I recall it, to nodal radial lines as being inactive?

A. I refer to radial nodal lines and circular nodal lines, both.

XQ. 271. Then what answer can you give me to this question: Do you or do you not agree with Dr. Miller's statement that any portion of a Fada cone in normal operation will give off sound of any frequency that is reproduced by the loud speaker?

A. I do not agree with that. I believe it is quite likely that some of the portions of a cone are inactive in producing sound at certain frequencies.

XQ. 273. And what portions of the cone do you think are inactive in producing sound at low frequency?

A. At low frequencies, particularly where the

cone is moving practically as a plunger, I believe the entire area of the cone is active.

XQ. 274. Is what?

A. The entire area of the cone is active in producing the sound.

XQ. 275. And what portions of the cone do you think are inactive in high frequencies; that is, the higher frequencies to the audible limit?

A. At the higher frequencies toward the upper end of the useful range, that is, towards 5000 cycles, I believe the areas at larger radii are probably inactive particularly where there are nodal lines.

XQ. 276. And illustrating that in the sand patterns of the defendant's cone, I call your attention to Defendant's Exhibit No. 32, and will you point out and describe with reference to that exhibit, what portions of the cone are giving off the sound waves?

A. This pattern was taken at 400 cycles and I believe substantially the entire cone was active at that frequency in producing sound.

THE COURT: What?

THE WITNESS: And I believe substantially the entire cone was active at that frequency in producing sound at 400 cycles, that is, by its plunger motion, piston-like motion or vibratory motion in the body of the cone itself, well, at 400 cycles, the cone is flexing so little it is substantially a plunger. At that point it is starting to depart from what appears to be the plunger action, and its departure is more evidenced.

XQ. 277. And on the cone, the radial black lines indicate the portions of the cone which were not vibrating as distinguished from plunger-like action; is that right?

A. I would not say so. The black lines indicate that the relative motion existed between the light areas and the dark areas. That is, the radial nodal line of

this exhibit might very well have been moving itself as a plunger with the rest of the cone, but the light areas indicating the loops between these radial nodal lines were moving with respect to each other.

XQ. 278. And referring to the 6400 cycle sand pattern, Defendant's Exhibit No. 37, would you say that the sound waves were emanating substantially from the entire surface of the paper cone?

A. No. I would say it is very doubtful. I think as a matter of fact, that they would be emanating principally from the central portion of the cone.

XQ. 279. By that you mean the inner edge?

A. The area near the apex of the cone or near the voice coil.

XQ. 280. What do these white spaces intermediate to the edges mean in the sand pattern?

A. It means that they are the portions of the structure which are indicating the most violent vibrations.

XQ. 281. And undergoing vibrations in the form of waves more or less, are they not?

A. Yes. The adjacent light areas are moving in opposite direction, and they are so close together that the air is undoubtedly circulating between those nearby areas. Furthermore, the sound wave initiated at the center of the central portion of the diaphragm travels so much faster than the wave does in the material itself, as a matter of fact, five times faster, that it is well away from the diaphragm by the time the wave has reached these areas in the outer portion of the diaphragm.

XQ. 282. And if it were possible to take a cross-section of the diaphragm at any moment, the wave would be somewhat as illustrated in your left-hand column of the Chladni figure?

A. I might explain that.

XQ. 283. Will you answer that first?

A. It would depend upon what type of vibration is employed. If the vibration is one impulse such as a staccato note or a pistol shot or something slightly longer in duration than that or in the lower tones a bass drum, it might not look like that at all, because the single impulse would travel out, but if the impulses were a successive and continuously applied vibration actuating the structure, then you would have a wave traversing continuously and you would get a cross-sectional view such as shown in Fig. 2-A.

If, however, it was a single impulse, the wave in the beginning in a cross-section view would show at a central portion and a short time later it might show the single wave off the diaphragm until it reaches the edge.

XQ. 284. You understand that the sand patterns are not made by a single impulse?

A. No, with a continuously applied vibration.

XQ. 285. I think that you have stated that the white spaces intermediate the two edges of the cone indicate vibration of the paper at those points?

A. Yes, they are loops of vibration.

XQ. 286. Do those vibrations create sound?

A. Not necessarily.

XQ. 287. Taking this sand pattern, will you say that these vibrations indicated in that sand pattern did not create sound?

A. I could not say exactly. I am giving you my views on the relative amounts of sound produced and my reason in saying that is that the sound is produced in the central portion of this particular figure even though these areas are vibrating, the ones more than half-way, or more than half-way off the cone structure radially, that although these areas are compressing and rarefying the air in the immediate vicinity to them, that immediately adjacent thereto there is another area acting in exactly the opposite sense so that

those two adjacent areas tend to neutralize each other, and although the compression and rarefaction is going on, the net result may be no sound or a slight sound.

XQ. 288. I think that you stated in your article: "Unfortunately the receiving equipment at that time did not permit the broadcast listener to appreciate the quality of transmission."

What time were you referring to, around 1925, 1926?

A. That is referred to in the line before, in the spring of 1922.

XQ. 289. And then in connection with the same subject you stated:

> "The loud speaker, being a device which produces the sound, is generally blamed for all the deficiencies of the receiving system including those due to poor receiver, vacuum tubes, batteries and at times even the deficiency of the broadcasting."

That was correct at that time, was it not?

A. It is even still true.

XQ. 290. And you also stated in your article:

> "An unfaithful reproducer will, however, smooth these rough edges of the sound and give a more pleasing tone. This deceives the listener into believing that the more faithful speaker is faulty, whereas the facts are that the speaker is faithfully reproducing the voice which has been distorted by the vacuum tubes."

In the demonstration that was given by you between the paper cone with the paper rim as compared with the standard Fada loud speaker, Plaintiff's Exhibit O for Identification, you stated, as I understood you, that the Fada loud speaker was more efficient at higher

frequencies in that the paper rim loud speaker did not reproduce the sound similar to a needle scratch. Is that an illustration of the fact that an unfaithful reproducer will, however, smooth these rough edges of the sound and give a more pleasing tone as stated in your paper?

A. No, it is not.

XQ. 291. Why is it not?

A. I was attempting to say in saying that the Fada speaker was more efficient at high frequencies that there was a difference in the two and that at these extreme frequencies the Fada speaker being more efficient gave more of the sibilant sounds. However, I believe that the other model with the paper rim was amply efficient in this regard to give what would be termed faithful reproduction. Might I remark about your quotation, what the connection is? I do not get the connection of your quotation.

XQ. 292. I will try to make it clear here. Would you say that in that comparison that you made that the Fada reproducer or loud speaker was a more faithful reproducer than the Plaintiff's Exhibit 31 with the paper hinge as demonstrated?

A. No. It would be difficult to say just which was the most faithful. It might have been that the Fada speaker were less faithful and overemphasized the needle scratch.

XQ. 293. As demonstrated here in court you say that the Fada reproducer was not more faithful than the paper rim cone Plaintiff's Exhibit 31, is that correct?

A. Yes, I do not think it was more faithful.

XQ. 294. And yet as you testified previously you state that the Fada speaker was more efficient at frequencies beginning around 3500 cycles, is that right?

A. Yes.

XQ. 295. And you could hear 3500 cycles in Fada plainly and you could not hear them plainly in the paper rim structure, is that right?

A. Yes.

XQ. 296. And also you testified at one time under cross-examination that——

A. Pardon me. You say could not hear them on the other structure, is that the question and I answered yes?

XQ. 297. I do not know what the question was.

A. I want it repeated.

XQ. 298. You seem to have no hesitancy in answering it. If you misunderstood it I will be willing to re-read it to you.

(XQ. 295 repeated as recorded.)

A. I will change that answer. No, I could hear them plainly in both structures. In the Fada structure they were louder than in the paper rim structure and I said the efficiency is higher in a device when it is resonant and sometimes, as I described in previous testimony in this case, we get resonant conditions which are objectionable. At these resonant conditions you get extremely high efficiency, but that does not necessarily mean that the device is very faithful.

XQ. 299. And you also testified in cross-examination that you considered the essential frequencies in a loud speaker device to be between what figures?

A. 50 cycles per second and 5000 cycles per second.

XQ. 300. And in connection with this paper rim structure you are familiar with various types of cones that have been built and demonstrated as Hopkins cones in the various litigations employing a paper rim?

A. Yes.

XQ. 301. And I think that you testified that the paper rim would vibrate and give off sound waves but of a somewhat negligible extent?

A. It depends largely upon the area of the rim. Obviously the area adjacent to the ponderous rings could not produce any sound and obviously the area actually connected to the conical portion at the lower frequencies will produce sound in the same manner that any material connected to the conical portion will produce sound.

XQ. 302. You attended the trial in the Crosley case in Cincinnati, did you not?

A. Yes.

XQ. 303. You know Mr. Ben E. Brown?

A. Yes.

XQ. 304. Did you assist him in any way in preparing photographs of a Hopkins speaker that was built for demonstration purposes?

A. No, I did not have anything to do with those photographs.

XQ. 305. But you are familiar with them?

A. Yes, I am familiar with them.

XQ. 306. And they checked up with your knowledge of the subject?

A. Yes, he prepared the photographs himself.

XQ. 307. And they were offered in evidence as you recall by the Lektophone Company as part of its case?

A. Yes.

XQ. 308. And I call your attention to the photograph of a sand pattern of a Hopkins device at 125 cycles per second which was part of Plaintiff's Exhibit 20 in the Crosley case and I ask you where is the rim in that structure?

A. The rim is the white annular ring of the photograph.

XQ. 309. And the fact that it is shown white shows that it vibrated, does it not?

A. The rim was made of white paper I believe. The cone itself was made of a darker shade of paper.

XQ. 310. But that is a photograph of a sand pattern?

A. Yes.

XQ. 311. And the fact that it is shown white on this photograph shows that that portion vibrated, is that right?

A. Yes, the rim vibrated, although the area immediately adjacent to the rings, of course, did not vibrate.

XQ. 312. And that 3200 cycles per second, the rim likewise vibrated, did it not, right up to the edge of the support to the annular rim?

A. Yes, the rim vibrated.

MR. DARBY: I offer in evidence the photograph marked Plaintiff's Exhibit 20, you do not mind my offering it at this time rather than having it marked for identification.

MR. DAVIS: No, I have no objection.

MR. DARBY: I offer in evidence the photograph which was part of Plaintiff's Exhibit 20 in Lektophone Corporation v. Crosley Radio Corporation, being a photograph of the sand pattern of the Hopkins cone at 125 cycles per second.

(Received in evidence and marked "Defendant's Exhibit No. 41.")

MR. DARBY: I offer in evidence another photograph of the Plaintiff's Exhibit in the same case, being a photograph of sand patterns of a Hopkins cone operated at 3200 cycles per second.

(Received in evidence and marked "Defendant's Exhibit No. 42.")

THE WITNESS: Referring to the subject of sound-boxes, such as are used in conection with phonographs, when used in connection with a horn of large size extremely low notes can be produced if the horn is made large enough in diameter.

These low notes whether they are produced from a sound-box on a phonograph or from a radio loud speaker, have the same wave length in the air itself irrespective of what produces the note.

In the phonograph art it is necessary to separate the front from the rear of the sound-box chamber, in order to enable it to produce low notes, because you are using the action of one side of the diaphragm only in producing the sound. The side of the diaphragm facing the sound-box is the active side and actually produces the sound that you hear. The sound given off the other side is negligible.

As to what would happen if the sound waves of a low note having a substantial length was allowed to slip over the edge of the cone and get behind the edge of the cone, the net result would be very little production of sound. Due to the fact that the air would slip around the edge and get in back of the cone, and also due to the fact that you are not actually compressing the air in the sound-box which you are trying to do.

As to whether or not that is one of the reasons why they use a horn in a sound-box, I hardly believe so because you see the operation of the sound-box and a horn is such that a low tone is not really created until you reach the mouth of a large horn and then it is so far removed from the diaphragm that you do not need anything between it and the diaphragm to prevent it from circulating it to the other side.

A horn does not prevent a low note wave from slipping over the edge of the diaphragm and getting

in back of the diaphragm itself, because the wave is not formed. All you are dealing with in a sound-box is pressure. You have to establish your pressure first and let it expand along the contour of the horn and finally released at the mouth of the horn and there you have a sound wave.

I do not consider the sound-box and the horn of a sound-box horn combination as a baffle. Yet I admit that you get very little sound unless some means was taken to prevent the fluid air from in front of the diaphragm from slipping around and getting in back of the diaphragm. That means has to be a horn. For instance, it could not be a tube. In other words, it cannot be just merely a separating structure. It has to be a horn and so tapered that the high-pressure impulse at the throat of the horn is permitted to expand. If you apply the same thing to a tube you would not get the low-frequency sound wave.

The function of a baffle is quite different. You are dealing with a low-pressure impulse in which the wave is formed much nearer to the diaphragm, so that you are actually preventing the partly formed sound waves from intermingling.

I do not think that a horn does that at all in a phonograph, because the waves are not formed until they are practically at the mouth, these low-frequency tones that we are discussing.

I referred to the high pressures in a sound-box. As to what causes the high pressure, the restricted chamber on one side of the diaphragm which is in itself a sound-box and the action of the diaphragm compressing the air in the chamber makes a very high pressure impulse, which is admitted to the throat of the horn.

In the sound-box art, that is a flexural movement of the diaphragm, in some sound-box art it is a flexural movement and in other structures it is more of a piston nature. In the sound-box art, the diaphragm flexed and

caused a compression of air in the sound chamber, that is, either flexed or moved as a plunger and compressed the air in the sound-box chamber.

The air goes from there and passes to the small opening at the base of the horn called the throat. When it is admitted to the throat of the horn it is not in any way a sound wave but a high-pressure impulse which pressure is gradually lessened as the impulse travels out toward the opening of the horn.

I listened to a sound-box of a phonograph with the horn removed many times. I heard the reproduction of high frequencies only and a complete lack of bass. I have listened over a telephone receiver. I have laid that telephone receiver on the table and heard it speak. I have noticed an entire absence of bass notes in that, that is, low frequency notes. I put it up to my ear and I could hear everything beautifully.

You are compressing the air in the chamber between the telephone receiver and the diaphragm of the ear drum. The sensations caused, depend upon different phenomena there, that is, the lower tones are more pronounced, because the air is actually compressed in that sound-box existing between the diaphragm of the telephone receiver and the diaphragm of the ear, the pressure on the diaphragm being proportional to the displacement of the diaphragm rather than to the velocity of the diaphragm as in the case of the loud speaker.

The lowest frequency I have ever been able to hear on the phonograph and horn is 130 cycles. I mean on commercial records; specially constructed records go to 25 cycles. The wave length of 25 cycles is 45 feet. The length of the horn that I was using when I heard that was relatively small in comparison. It was two or three feet. In length, probably a foot and a half in diameter. The length of my horn was a very small fraction of the wave length.

The record used was a simple tone at 25 cycles, and the response was relatively weak for the amount of vibration recorded on the record. A commercial record of that sort, if you had the rest of the audible frequencies on it, the effect produced would be that the higher tone would completely drown the lower tone. This was just a laboratory experiment to hear the low-tone record.

Getting back to the commercial record, the frequency that I said that I heard was 130 cycles. The length wave of 130 cycle is about 7 feet—about 7½ feet. The length of the horn that I used when I heard that was about 3 feet.

As a matter of fact, I could have used a much smaller horn. It is a matter of proportion of the tone to the ear to the high to give the quality and the amount of base. And the horn, I used was a fraction of the wave length.

An over-tone is the harmonic tone of a resonator when vibrating at its fundamental, and they are classified as, first, second, third and so on, over-tones meaning that if the resonator were vibrating at 100 cycles, 200 cycles would be the first over-tone. They are multiple frequencies. In music, however, there are slightly different relations—the first case I gave was in electrical circuits—in music, however, and in vibrating systems, you have over-tones that are fractions, fractional increases, that is, you can get three halves and so on of fundamentals.

You always get over-tones in radio reproduction. They exist in the actual generation of the electrical impulse itself on a record or from the original sound impulse by means of the microphone, and all that has been successfully done so far is to minimize the production of the over-tones, without attempting to produce a simple tone. Distortion emphasizes over-tones. Amplifica-

tion and distortion is resulting therefrom, emphasizes it.

The Fada loud speaker, for example, reproducing an orchestral selection, reproduces, I would say, very well between 50 cycles and 5000 cycles. The over-tones of the orchestra would have to go much beyond that, in order to distinguish the highest note of a violin, from the highest note of a flute, of the same pitch you would have to be capable of reproducing the harmonics necessarily involved in the violin note which may extend to 10,000 cycles. Very frequently in radio broadcasting reception, reproduction is limited to about 5000 cycles, and that slight differentiation in the higher notes is not taken care of.

That is, it would reproduce over-tones up to the limits of reproduction of the cone itself. And therefore the actual sound wave vibration of the Fada loud speaker in actual use is a rather complex pattern, if a sand pattern were made of it. It would be a continually shifting sand pattern. It might have in one instant a simple frequency; it might at the same instant be subjected to a composite of several frequencies, and it would be a very complex pattern continually shifting.

RE-DIRECT EXAMINATION.

This device that is shown in Fig. 3 of the paper which I read and which Mr. Darby brought to my attention, and which is called the Phonetron in the paper, that is the device which I testified earlier that I manufactured and sold in 1921.

As to what I used as the conical diaphragms for this Phonetron device; that is where I got them—the diaphragms of the Phonetron were purchased from the Pathé Phonograph & Radio Corporation—that is wrong—the Pathé Phonograph Company, who had ma-

chinery for making them out of one piece of paper at that time.

I was familiar with the phonograph that was made and sold by the Pathé Company known as the Actuelle. That was made and sold before I developed the Phonetron.

As to whether or not the diaphragms of the Phonetron were the same as the diaphragms that were made and sold in the Actuelle phonograph, they were the same, made by the same process and of the same material.

MR. DAVIS: I offer in evidence a copy of the paper in question as Plaintiff's Exhibit No. 34.

(Received in evidence and marked "Plaintiff's Exhibit No. 34.")

In a faithful loud speaker, as to what must be the relation of the efficiency of reproduction at one frequency, one-tone frequency, to the efficiency of reproduction at another tone frequency, a faithful loud speaker should produce all tone frequencies within a useful spectrum, from 50 up to 500 cycles, with the same output of sound for the same uniform input of electric power; that is, the response of a loud speaker at different frequencies should be uniform before it can be considered faithful.

My attention is directed to the paper of Maxfield & Harrison, which was put in evidence as Defendant's Exhibit No. 7, and was referred to by Dr. Miller, particularly to the frequency diagram that was discussed by Dr. Miller. The curves on that diagram are efficiency curves, showing the efficiency of the respective loud speakers at different frequencies.

The efficiencies of respective phonographs. I believe curve A refers to the phonograph structure of Fig. 19 on that paper, and curve B refers to one of the

best commercial machines previously on the market, which I assume was also an original machine.

The graph here shows the relation between frequency plottings on the horizontal axis and the transmission units, which really in themselves mean the sound output; and if the curve were a horizontal line, the sound output would be uniform throughout the range between 120 cycles and 5000 cycles. Yes, I examined this with the glass, with those pencil figures on the drawing here. However, below 120 cycles, the reception drops to zero, and it does not reproduce below that. They have termed it a band pass filter, because it passes this band of 120 cycles to 5000 cycles. The sharp cut-off at 120 cycles is due to the size of the bell opening of the horn. The larger the bell opening of the horn the lower the cut-off frequency.

I said on cross-examination that the steepness of a cone, other things being equal, affected or might affect the efficiency of reproduction at different frequencies. Now, I will tell you whether the making of the cone steeper increases or decreases the efficiency at high frequencies, other things remaining equal.

The steeper the cone the greater its efficiency at high frequencies.

RE-CROSS-EXAMINATION.

As to how many of these Phonetrons I made and sold, I do not recall. It was more than fifty and less than 100. They were sold for radio amateurs. Broadcasting was not produced then; there was no market. I discontinued that structure because the amateur market was very limited. It was not until broadcasting came along that it became a real market and could support a manufacturing concern. When the broadcasting market came along there was created a demand for loud-speaking devices.

I referred to the Pathé Actuelle. The diaphragm structure of the Pathé Actuelle was like that shown in the Davis and Joss patents, Defendant's Exhibit No. 40. That was used directly in connection with the phonograph. That likewise was discontinued.

MR. DAVIS: I want to offer in evidence the charts to which Mr. Farrand referred; and I offer in evidence the chart marked "Figure 1" as Exhibit No. 35, and the chart marked "Chladni figures" as Plaintiff's Exhibit No. 36, and may it be understood that we will substitute photostat copies for those to be actually marked.

(The chart marked Figure 1 was received in evidence and marked "Plaintiff's Exhibit No. 35.")

(The chart of Chladni figures was received in evidence and marked "Plaintiff's Exhibit No. 36.")

MR. DAVIS: And while I am at it, I should like to have marked for identification, so that it will be available to the Court, and Mr. Darby suggests this, the Fada cone and rings removed from the driving unit, which was used during the examination of Dr. Miller, both by Mr. Darby and myself, and I think it would be sufficient to have it here marked for identification, and not put it in evidence.

THE COURT: Very well.

(The Fada cone and rings were received and marked "Plaintiff's Exhibit Q for Identification.")

MR. DAVIS: To make the record complete, I offer two Brandes loud speakers, which are marked

respectively for identification B and C, only for identification, because it seems to me unnecessary to put them into the record, so that if there is no objection I will leave them here marked for identification.

MARCUS C. HOPKINS.

MARCUS C. HOPKINS, was called as a witness in rebuttal, on behalf of the plaintiff, and having been duly sworn, testified as follows:

DIRECT EXAMINATION BY MR. DAVIS:

I am the inventor and the patentee of the patent in suit.

I had a very good technical training in the grammar and high school at Washington and some special training in Columbian University, and by my father, in preparation for following in his footsteps in the patent business, and I had a very thorough musical training covering about thirteen years with the best of teachers. I played the violin.

I was very much interested in acoustic phenomena for a long time scientifically, and I finally got very much interested in mechanical reproduction of music, which was at that time the phonograph business. I thought it might be very much better than it was. It had its shortcomings and I engaged with Mr. Plum in Newark in experimenting and designing and building and selling phonographs from about the year 1905, or for four or five years.

After that I had an opportunity to choose what was most to my liking and I went up to Mr. Edison's laboratory, where I thought I could learn considerable, and there I worked the best part of two years for him as an experimenter. At that particular time we were in-

terested in the horn and sound box combination phonographs, and there was a transition period between the straight observable horn and the cabinet machine where the horn was enclosed in the cabinet and out of sight and more sightly device, and in their efforts to put the horn inside of the machine Mr. Edison became interested in finding out what he could about the shape of the horn.

It seemed to spoil it when we got to bending it up and putting it in cabinets, and he put me on a line of experimentation to find out how the horns worked. There was not very much in the literature, and what could be done with them. I made a great many of them.

I had available all of the laboratory equipment which consisted of machine shops, chemical laboratories, physical laboratories, a storehouse in which had been collected a little bit of pretty nearly everything from every part of the world.

I experimented a great deal on sound-box and horn combinations that already had been made up to that time and then I began to make horns out of various materials, a great many materials and a great many shapes and sizes and finally arrived at some that were outstanding for their apparent improvement but they contained things that were drawbacks. There were distortions, and I should say distortions that we did not seem to be able to remove and I practically reached a standstill so far as I believed I could go at that time and with Mr. Edison's consent I decided that these troubles were in the sound-box and horn combination and we did not know how to get them out and that I would try some of the direct propagation methods, there were a number of them that existed at that time, we might call them sound-board methods.

There were a number of musical instruments that depended on the direct propagation of sound by shaping a broad surface in contact with the air and the horn

was used solely to get enough energy on a broad surface of air and I felt that if we could do it directly we might evade these peculiarities that seemed to be inherent in the horn and sound-box combination.

So I started by trying all the sound boards that were available to us at that time, the piano and the guitar and the zither and a number of those instruments and found them too heavy and too stiff and began to make my own sound boards, much lighter and more delicate and with increasingly good results as they got lighter and more delicate.

Those improvements of course came gradually and we finally got to making these sound boards out of paper. We made a sound board where the top and bottom were paper with several divisions and in order to get the lightness and requisite stiffness as a purely engineering proposition, I resorted to the conical form of a cone of paper.

I did not look forward to anything other than a very light stiff device, but the moment we began to play with it there was a jump in the results, that at that time was perfectly marvelous and astonishing.

We began to get real fine results right away. We began to study this form of device alone, just the cone part of it. It was the same thing that we have here, the Starling & Cole cone without any attachments at all. It worked very well except that it was subject to these blasting effects that have been demonstrated here and was not a very practical device to use if you wanted to build a phonograph.

So the experiments continued and we began to mount the thing and try means of suppressing the wave in the paper and mounted it in various ways so that we were trying to keep the axial or piston movement and take the wave out, but the first experiments of suppressing the wave also affected the result as we had already obtained it.

As to what sort of experiments those were, it was mounting it on various supports such as felt and paper and we very shortly found that we could not get paper to go over the front of the cone.

We mounted the cone on a flat diaphragm of paper first and as I remember the first real good one was produced from that paper cone mounted on a paper diaphragm and the flat part was cut out of the cone.

Within the bell of the cone was cut out. That flat paper had been mounted on a wooden ring, a rather heavy wooden ring, and in drying it became very taut like a drum head, and after the middle had been cut out we glued the cone on to the flat part, and after the middle had been cut out we had a wonderful result.

From that time on we made many, many of these structures changing the factors as to size of the cone, and the material of the cone, and the angle of the cone and the width of the edge.

We recognized that there was something remarkable in this structure and we found that by changing these factors we could change the result in many different ways and of course these subsequent experiments were to get the result that we were after, which was the reproduction from the phonograph record that would suit us at least equally or better than came from the phonograph at that day.

The phonograph was particularly lacking in basses. The basses were there but the quantity of bass as compared with the rest of the range of the piano was deficient and one of the first things which we recognized with the cone was that we had the ability to increase that amount of bass. We built the cones up to size beyond the mechanical possibilities that we had then and down in size to a point where they did not give satisfactory results.

Going downward we found that the first thing we lost was the bass, and it was rather proportionate to

the amount that we lessened the diameter of the structure. We found that we could do very satisfactorily, and very satisfactorily for those times, with the structure which we finally arrived at and which is illustrated in the patent.

The drawings of the patent drawings were drawn directly from the finished machine.

CROSS-EXAMINATION.

As to my occupation, at the time my application for patent was filed, I was engaged in the patent business with Pennie, Davis, Marvin & Goldsborough. That is the precedessor of the present firm of Pennie, Davis, Marvin & Edmonds.

I was writing specifications and prosecuting applications for patents. I prepared my own specification in great measure, but I had the idea that perhaps the inventor was not the best attorney and I, after my preliminary preparation, turned the whole business over to Mr. Davis. Mr. Davis of course had far more experience in the preparation and prosecution of patent applications than I had at that time. I did not keep very close touch with the prosecution of the case.

XQ. 21. You have previously testified that you did, have you not?

A. No, I do not think I did. I did not keep very close touch. I knew about the early stages of the prosecution.

XQ. 22. And from that I gather that you did not keep any close touch with the later stages?

A. No, I did not, not very close.

XQ. 23. You were not familiar with what was being done at all?

A. Not at that time. I was in Rochester.

XQ. 24. And when was that?

A. That was from 1914 on, the latter part of 1913.

XQ. 25. The latter part of 1913?

A. I think so.

XQ. 26. So that you had very little connection with the prosecution of your application from the latter part of 1913 until the patent issued, is that right?

A. I should say very little.

XQ. 27. Did you know anything at all about it?

A. I only knew that it was going on in a more or less satisfactory manner.

XQ. 28. But you did not know the substance of what was transpiring?

A. No, I left that to Mr. Davis.

XQ. 29. You felt sure it was in good hands?

A. Absolutely.

XQ. 30. And you were not interested in the subject matter yourself other than with the knowledge that it was in good hands?

A. That is all.

XQ. 31. You were quite enthusiastic about this device of yours when you completed it and got it started on its way towards a patent?

A. Oh, yes, naturally.

XQ. 32. And quite naturally likewise you went over the application as originally prepared pursuant to your original draft, did you not, before you executed the oath?

A. Yes, I was very interested in it.

XQ. 33. And it correctly set forth the facts?

A. As correctly as we knew how at that time. It was a rather difficult proposition. I think you will appreciate that from what you have heard in this court.

XQ. 34. Yes, I do. So much so that I am wondering why you made this statement in the application as originally filed?

A. I will try and tell you.

XQ. 35. "Compressed fibrous material, such as hot pressed paper or fiber, has been found to act satisfactory, but I prefer to employ hard rubber or vulcanite,

as it is more easily handled, is less affected by weather conditions, and lends itself to the production of a more finished commercial product. The hard rubber is pressed into shape while hot from the sheet and allowed to cool in the die. If a polished sheet has been used the finished tympanum will have a beautifully polished appearance."

You made that statement when you originally made your application?

A. I am quite sure I did.

XQ. 36. And had you ever made a diaphragm of that nature that you advanced as your preferred form at the time you filed your application?

A. I made that type of diaphragm, but I do not think I advanced that as my preferred form. At the time we were having extreme difficulty in overcoming an objection of a delicate paper device as a manufacturable thing and I was making every effort to get something that was less fragile and I made a very thin, hard rubber diaphragm that was very, very good with the hopes that I could overcome the manufacturers' objections, they would not have a thing to do with this fragile paper thing, and they said it was impractical. The hard rubber diaphragm did very well, not nearly so good however as the preferred form that was set forth in the patent.

XQ. 37. I think you stated that your father had been a patent attorney and you received patent training from him?

A. I did not receive patent training from my father. I received the technical work that was obviously intended to fit me for the patent work.

XQ. 38. And prior to the time that you filed your application for patent in July, 1913, how much experience had you in patent work?

A. I was in the patent business in various capaci-

ties starting rather as an underling from 1900 to about 1905; no, from about sometime in 1899 to about 1904.

XQ. 39. Roughly about five years?

A. About five years.

XQ. 40. And how long had you been with Mr. Davis' firm?

A. I went with Mr. Davis' firm, I think it was in the latter part of 1910.

XQ. 41. And you were with them continuously up until 1913?

A. 1913, yes.

XQ. 42. So that you had had at least seven years' experience in the patent business?

A. Yes.

XQ. 43. And consequently when you stated in your patent application that you preferred to employ the hard rubber or vulcanite, you did not intend to mean that that was preferred form?

A. I did not mean that that was the best playing form. At that time it was most necessary not to have an impractical material. It would not work at the seashore at that time, that is, in the period that I am speaking of.

XQ. 44. Let me read you part of your testimony in the Crosley case on the same subject.

MR. DAVIS: Will you give me the pages?

MR. DARBY: 28 in the record on appeal.

XQ. 45. "XQ. 96. Now, isn't it true, Mr. Hopkins, that you really at the time you filed your patent specification, preferred to use hard rubber or vulcanite for the diaphragm, rather than paper?

"A. No, I would have preferred that if we had gotten the hard rubber to do it, but it wouldn't do it. We were trying it about that time."

A. That is true.

XQ. 46. You so testified?

A. Yes.

XQ. 47. "XQ. 97. Well, I want your definite statement. At the time you filed—you signed that patent specification, being a patent solicitor and having worked on it——

"A. Leave that out.

"XQ. 98. All right. You did not prefer hard rubber or vulcanite for the diaphragm? Will you make a positive statement to that effect or against it, one of the two?

"A. I won't make a positive statement. I will qualify it. If you could make it work as well as paper, yes, we preferred it.

"XQ. 99. Well, now, isn't it true that in your application as originally filed, after the sentence which has been retained in your original patent ending in the number twenty-nine 'compressed fibrous material, such as hot pressed paper or fiber, has been found to act satisfactory' you proceeded to say: 'But I prefer to employ hard rubber or vulcanite, as it is more easily handled, is less affected by weather conditions, and lends itself to the production of a more finished commercial product. The hard rubber is pressed into shape while hot from the sheet and allowed to cool in the die. If a polished sheet has been used the finished tympanum will have a beautifully polished appearance'?

"A. We had made those hard rubber diaphragms and gotten very fair results but not up to paper, by any means. But we had seventeen years to look forward to the fact that we might get them, and unquestionably we would have preferred it if we could have gotten it, and would today.

"XQ. 100. My question was more direct than your answer. I asked you whether at the time you did not make that statement in your patent application?

"A. Is it in there?

"XQ. 101. Yes, it is.

"A. Then we made it.

"XQ. 102. Then you were not sold on the use of paper at that time, is that correct?

"A. Yes, I was sold on the use of paper at that time. It was the best thing I had.

"XQ. 103. And you were trying to mislead the public in your statement in your sworn patent application, were you?

"A. No, I was trying to give the public something that would be more durable.

"XQ. 104. Why did you say you preferred it then, if you did not?

"A. Because it was more durable. Now, if you could only convince the public that they did not need quite so much volume, it would have been better all around; but we couldn't."

You so testified?

A. Yes, I did.

XQ. 48. Now, you referred to working at Mr. Edison's laboratory, and as I understood you it was while you were at his laboratory working on this general subject that you invented this cone; is that correct?

A. It was while I was there that I made many of the preliminary experiments, and I made the first cone just before I left there, maybe a couple of months.

XQ. 49. What was your purpose of working with Mr. Edison, were you working for Edison?

A. Oh, yes.

XQ. 50. What were you directing your attention to, developing some sound reproducer?

A. Yes.

XQ. 51. And did Mr. Edison ever adopt your sound reproducer?

A. No, when——

XQ. 52. That is all, you have answered my question. And I understand that the drawings of the pat-

t in suit were made directly from an actual struc-ure, is that right?

A. Yes.

XQ. 53. And the actual structure that you made s far as the cone portion is concerned, so far as I nderstand it, you made the rim out of a separate iece of paper, did you not?

A. Yes.

XQ. 54. Why did you make the rim out of a sep-rate piece of paper and then paste it on the conical ortion rather than making it all out of one piece as hown in the drawings of the patent?

A. We did not have any machines to assume that hape. You cannot bend a piece of paper into that hape.

XQ. 55. You cannot?

A. No, you have to draw a piece of paper into hat shape and it requires machinery and quite a lot f development work that it was not necessary to do hen. We pasted it on to a flat sheet.

XQ. 56. Then to be able to make a cone out of ne piece of paper it would have required a consider-ble amount of development work which had not been one up to that time?

A. Yes. A lot of development work has been done n doing that and it has not resulted in very much yet.

XQ. 57. It would be almost as difficult today to ake it out of one piece today as it was then?

A. It would be difficult. Of course, a manufac-urer building machinery for the purpose would find ittle difficulty. That was not my position at that time.

XQ. 58. And of course at the time that you were arrying on this work you never thought of using your one for loud speakers in radio, did you?

A. My knowledge of radio at that time consisted f not much more than——

XQ. 59. Will you answer my question?

A. I am going to.

XQ. 60. But I ask for a direct answer to my question, which is, at the time you developed this speaker in 1910 or 1911 or thereabouts, had you any thought of using your cone diaphragm as a loud speaker for radio?

A. No, radio had not been developed then and unless a thought of using it for telephone purposes might be connected with your question——

XQ. 61. Do you think that the thought of using it for telephone purposes is connected to radio?

A. I did not foresee the development of radio, no. I did not foresee this development.

XQ. 62. Then your answer to my question whether you foresaw any use of your cone for the purpose of a loud speaker in radio is "No," is that correct?

A. So far as radio is concerned, it is "No."

XQ. 63. When did you first think of using your cone for radio purposes?

A. I do not believe I thought of using my cone for radio. I think Mr. Farrand was the first person who adapted it for radio.

XQ. 64. When did you first think of first using your cone for radio?

A. I did not think. I say Mr. Farrand thought of it.

XQ. 65. You never thought of it up to the present time, have you?

A. Think of using it for the radio?

XQ. 66. Yes.

A. I understood your question was when I first thought of using it or when I conceived of using it for radio. I answered your question that way. I first saw it used for radio by Mr. Farrand.

XQ. 67. When was that?

A. That was the first idea I had that it was going to be available for that purpose.

XQ. 68. And when was that?

A. It is awfully hard for me to say.

XQ. 69. Do you say it was before 1918 or after 1918?

A. The device that has been testified to here known as the Phonetron, and it was in the early days of the existence of that.

XQ. 70. Mr. Farrand says it was sometime around 1921. Does that check up with your recollection?

A. It must have been.

XQ. 71. But it was subsequent to the filing of the patent in suit?

A. Oh, yes.

XQ. 72. I think that you stated that you were familiar with blasting of these cone structures that you were working with in 1910?

A. Oh, yes.

XQ. 73. You were?

A. Yes, I was familiar with the blasting of flat diaphragms and sound boxes long before that.

XQ. 74. What did you utilize as your source of sound in the cones that you were working with?

A. We utilized records in the main.

XQ. 75. And what was the power of those records which you were utilizing for your sound purposes?

A. I have not any measure of the horsepower to tell you——

XQ. 76. And what was the amplitude of vibration?

A. The amplitude of those records I remember measuring 1/1000th and as being a maximum amplitude, as being measured at one time on the cylinder records amounted to about 2/1000ths or 3/1000ths each way and on the disc record I discovered it was 4/1000ths each way from the tracking line on the record without any waves being impressed on it.

XQ. 77. You say two or 3/1000ths. Do you mean two or 3/1000ths of an inch?

A. Yes. That only occurred on the excessive cuts. Ordinarily it is extremely small.

XQ. 78. That was the maximum?

A. And it is still extremely small on the greater part of the range.

XQ. 79. Do you mean to say that with an amplitude of vibration depending upon a maximum movement of two to 3/1000ths of an inch, of those early records that you were able to secure blasting?

A. Oh, yes.

XQ. 80. With your cone structures?

A. Yes.

XQ. 81. These figures that you have given me, which for the cylinder records two to 3/1000ths and disc records four to 5/1000ths——

A. About 4/1000ths.

XQ. 82. Is that your rough guess?

A. No, I actually made some measurements once and hunted through a great number of records to find out what is the greatest amplitude I can find. That I am speaking of now of old type records prior to the filing of the patent.

XQ. 83. Yes, and I think you referred in one of these cases to these old type records as very inefficient as compared to the records of today?

A. Oh, yes.

XQ. 84. In the Sylo case you testified, did you not, before Judge Campbell?

A. Yes.

XQ. 85. And you made this statement——

XQ. 86. "Q. 24. So that a small cone"—and I will recall to you that you were talking about a small cone, smaller than nine inches in diameter—"so that a small cone would not produce those low tones, however you vibrated it, is that the idea?

"A. They would never produce the self-sustaining wave in air.

"Q. 25. At those frequencies?

"A. At those low frequencies of the desired efficiency that it is to make it a part of the audible spectrum."

A. Yes.

XQ. 87. You so testified?

A. Yes.

XQ. 88. Would you testify the same way now or would you modify that answer?

A. I would modify that maybe in the language used, but not in the meaning.

XQ. 89. What?

A. I say the same thing as far as the meaning went, but I might make it clearer in words.

XQ. 90. Go ahead. I will ask you the question right now. Do you say that a small cone would not produce low tones?

A. It would not produce the desired quantity of the low tones to balance the rest of the sound spectrum.

XQ. 91. But you do not mean by that that they would never produce a self-sustaining wave in the air, do you?

A. No, they would produce the high tones amply well.

XQ. 92. Would a small cone produce a self-sustained wave in air of a low tone?

A. It will produce a tone that will likely be away from the front. If you happened to be near that small cone you will get a very, very fair effect from the impression in the air. If you happen to be far from that cone you will find that the wave has spread out and lost its form to such an extent that a very small amount of the energy put on the air reaches that point at a distance, and when the term self-sustaining wave was chosen it was meant a practical production of a wave which would travel out into the air without sub-

stantially losing any great amount of energy by deformation.

XQ. 94. Then will you agree with me that the two questions and your answers thereto in the Sylo case, without the explanation that you have given to this Court, was capable of being misunderstood?

A. No, I do not think so.

THE COURT: What was the answer in the Sylo case?

MR. DARBY: They would never produce the self-sustaining wave in air.

By MR. DARBY:

XQ. 95. Let me ask you this, would you say taking a low tone of approximately 100 cycles per second, you said if you stood near the cone, by that you do not mean that your ear would have to be three inches from the cone, do you?

A. No.

XQ. 96. You could stand five feet?

A. It would depend on how big the cone is.

XQ. 97. Take any particular size cone.

A. Say a three-inch cone.

XQ. 98. You could hear it if you were away three or four feet, could you not?

A. It would not be what I would call a self-sustained——

XQ. 99. But you could hear it?

A. Yes, you could hear that frequency.

XQ. 100. And by what medium is the sound transferred from the movable diaphragm to your ear, air wave?

A. Yes.

XQ. 101. You would not call that a self-sustained air wave, though, would you, yes or no?

A. I would not call the wave started from a three-inch cone, if it were——

MR. DARBY: May I ask for a categorical answer to that question?

THE COURT: Can you not do that?

A. I would say no. That three-inch cone will make plenty self-sustained high tones. I was talking about low tones.

THE COURT: He was asking about frequency of 100 cycles.

THE WITNESS: That is what I understood.

XQ. 102. On the subject of blasting, that was a subject that was gone into at quite some length in the Crosley case?

A. I think that subject has been handled in all of the cases.

XQ. 103. You think so?

A. It seems to me that it has been discussed.

XQ. 105. You testified as follows, as appears in the record on appeal in the Crosley case, page 29, Mr. Davis:

"After we built these plain cones at the Edison plant we found that they blasted. That was a word that was carried down from the old sound-box art. We provided a flexible rim to overcome the blasting. As to whether we devised the rigid clamping ring so as to prevent the blasting that occurred in the plain paper cone—yes, we got that up to prevent the deformation of the circular form of the cone and to permit a plunger action. By deformation of the circular form of the cone I mean the bottom edge of the cone at rest was supposed to be a circle. When you played it, it would break up into standing waves a certain distance

from the edge on the surface of the cone and with nodes around that like what we call the bell action, and we wanted to stop that because that made tones of its own, as a bell does, and we wanted the device to respond only to the impressed signal, or as near it as we could get practically. I first learned about nodes as a schoolboy.

"XQ. 111. Then I understand you to say that the thing that was in your mind at the time you made that diaphragm up with the ponderous supporting rings, the rim, diaphragm and the conical portion as a combination, what you were aiming at was to stop these blasting sounds which you had noticed in plain conical diaphragms?

"A. That was one of the things. We were doing all of them at once. We had to have something to hold the cone.

"XQ. 112. Was that at all prominent in your mind as the reason for it?

"A. It became very prominent when we began to play them.

"XQ. 113. Had you begun to build it before you filed your patent application?

"A. Oh, yes.

"XQ. 114. Had you heard them play before the Lektophone Corporation against Sylo suit?

"A. Oh, yes.

"XQ. 115. Had you noticed that defect before the case of Lektophone Corporation against the Western Electric Company? Had you or not?

"A. Had I noticed the blasting effect?

"XQ. 116. Yes.

"A. That is a thing that I did when I made the orginal cone.

"XQ. 117. Did you ever use the word 'blasting' either in your patent, the patent application,

in your testimony in the Sylo suit or in your testimony in the Western Electric suit?

"A. I don't know whether I did or not. I don't remember.

"XQ. 118. Did you use that term in any remote way, referring to these diaphragms, in any of those places?

"A. I don't know whether I did or not.

"XQ. 119. Did you in the Sylo case attempt to explain the reason for that rim and rigid clamping provision in any of your devices?

"A. I have never, for very good reasons, attempted to explain the thing at all.

"XQ. 120. That goes for the Western Electric case too, does it?

"A. Yes.

"XQ. 121. In explaining your device to Judge Campbell and to Judge Thacher you held something back, did you, in argument——

"A. —I don't know whether you call it holding it back or not but I did not attempt to involve the thing to the extent that—it was not necessary to say any more than would be necessary for anybody to understand the situation.

"XQ. 122. In arguments with the Patent Office Examiner when your claims were rejected again and again were you familiar with the arguments that were made?

"A. I think I was at the time, most of them.

"XQ. 123. Did you suggest to your counsel the point that buzzing sounds and blasting were prevented by this construction?

"A. Oh, yes, we knew that in the old days. I don't know whether I ever suggested it to anybody or not. I can't remember that far back any particular conversation.

"XQ. 124. Well, did you or did you not mention at any time in your testimony in either of the two suits, Sylo or Western Electric, this effect for which you said in your direct testimony was the reason for the design of this rim diaphragm and ponderous ring?

"A. There was lots said in those suits. I don't remember whether I did or not.

"XQ. 125. Suppose I read you what you said in those suits?

"A. All right; that I can tell you exactly.

"XQ. 126. (Reading): 'When you get a bass tone from the apex of the cone that fundamental wave happens to travel away down near the periphery in a large area. When you get a cone structure and spring applied to the apex'—a spring edge, it is?'

"A. Yes."

By Mr. Darby:

Q. 106. Now XQ. 127——

The Witness: That does not sound like sense.

Mr. Darby: Mr. Davis is checking up my reading.

Mr. Davis: Do you want to follow it or listen?

The Witness: I will listen.

The Court: The witness desires you to read the latter part over again.

Mr. Darby: He read part of the sentence and interrupted to ask you a question, and the part of the sentence was:

"When you get a cone structure and spring applied to the apex"—and he interrupted you and asked——

"A spring edge, it is?"

"A. Yes.

"XQ. 127 (Continues reading): —a spring edge and a ring or an abutment so correlated that all of these frequencies applied to the apex will be damped off that cone from areas you can control by the angle and size and flexibility and all of the other factors, you are dealing with, when you get that condition you can practically reproduce in the art almost perfect reproduction of the original thing. I say almost because I do not like to say perfect, but the ponderable ring on the outside there, the energy travels from the apex down, it stores up in the spring portion, especially in the case of basses, which have been a thing which has been practically almost lacking, it stores up in that spring and bounces back some because some of that wave that went down the cone would probably require a larger cone if it could be made.'

"A. That is true."

You so testified in the Crosley case, didn't you?

A. I think that I did, and I could not do better than that.

XQ. 107. And your recollection now is no better than it was at that time as to what you testified in the Sylo case?

A. Yes.

XQ. 108. And you made no reference to blasting in the Sylo case?

A. I am not sure of that, Mr. Darby. I cannot imagine at this time that a discussion of these devices could have gone through without mentioning "blasting," but if it was not brought up, and it was not necessary to discuss it, why, I do not see why we should have discussed it.

XQ. 109. Then I may make the statement in all good faith, Mr. Hopkins, that you did not mention blasting in either the Sylo case or the direct testimony in the Western Electric case; does that fact surprise you at all?

A. It does surprise me slightly, but——

XQ. 111. Now, I would like to refer for the moment to the testimony that you have given in the other cases, on the size of the diameter of your tympanum, nine-inch minimum size. You have been questioned about that in the other proceedings in which you have testified, have you not?

A. I cannot remember all the testimony. I cannot tell which points I have testified to.

XQ. 112. Now, then, tell us. Let us start anew. You tell us now why you limited yourself to nine inches.

A. I will tell you, and I am only too glad to tell you that, Mr. Darby.

XQ. 113. I will be glad if you would.

A. I think there has been a great deal of misapprehension about that thing. It was an earnest desire of ours to make a disclosure of the best type of device that we knew how to do at that time. That was a long time ago, Mr. Darby.

XQ. 114. What?

A. That was a long time ago, and it was extremely difficult——

XQ. 115. How long ago was it?

A. It was about—I do not remember exactly.

XQ. 116. As far ago as 1913?

A. Before 1913.

XQ. 117. Mr. Hopkins, don't you recall that it was considerably subsequent to 1913 that it was stated that the size of the cone was essential?

A. Oh, yes, it has always been stated that the size was essential, that is, the minimum size, in order to produce an adequate base——

XQ. 118. You misunderstand me. Was it not long subsequent to 1913 that it was advanced by you or for you, that the minimum size of nine inches was essential; I think that is capable of a yes or no answer. Will you give me a yes or no answer to that, please, Mr. Hopkins?

A. I do not remember, at that time——

XQ. 119. That answers my question. Was it not subsequent to 1913; is that your best recollection; was it not subsequent to the time you filed your application for a patent?

A. I am not willing to say that it was after or before the preparation of the application.

XQ. 121. You started to explain when I interrupted, Mr. Hopkins, why the minimum size of nine inches was stated as the minimum size in your patent?

A. Yes, I am very anxious to explain, Mr. Darby; my memory is not sufficient to tell me whether we put that in when we first wrote the specification and when it was filed, or whether it was after, or not. That escapes me at this late date, but I wish to tell you why we put it in. I hope you will bear with me if I try to tell it in my own way.

THE COURT: Go ahead; that is the only way you can tell us.

THE WITNESS: The No. 1 element of the cone which we were talking about a little while ago, which is the cone, and which was the simple cone, as the eminent Mr. Starling and Mr. Cole also found, had this rather startling characteristic as an element of this combination—Messrs. Starling & Cole discovered that it blasted—we will use that term although it had a weaving, waving impression

at the edge, which gave rise to sounds that were not intended to be reproduced, and they seemed to have dropped the thing right there and not attempted any method of getting the good results of the cone without taking them up.

Now, from that day to this, I found it almost impossible to explain to a layman or even to an expert, the characteristics that are inherent in that cone, and when we came to getting a patent, it was a terrible proceeding to differentiate between this cone of that size, that was the element of the combination which we desired to be patented, and all of these other things which did work that way.

Now, it does not seem to have gotten any easier after all these years, and if my memory does not play me false, I personally gave up all hope of trying to explain how this thing worked. We have a great deal more information on it today, and I really believe I have a satisfactory idea of it today, but I did not have an intelligible idea to give them, and the easiest way out of it was to tell the public not to make the cone any smaller than that, or it would not give a result commensurate with the state of the art at that time. That is the explanation.

XQ. 122. Have you stated everything that you want to state now, Mr. Hopkins, as to why——

A. I am sure I do not know, Mr. Darby. There may be other things later.

XQ. 123. Let me finish my question first, and maybe you will know. Have you stated everything that you want to state now, as to why it was stated in your patent that nine inches was the minimum diameter for your cone?

MR. DAVIS: No—for the tympanum.

XQ. 124. Yes, for the tympanum; quite right.

THE COURT: That is, why?

XQ. 125. Why you inserted nine inches as the minimum size for your tympanum?

THE COURT: Yes, if I understand you, you are inquiring by that question—I am not sure that the witness and I have the same meaning from your question, but what I have been looking for all the time, and what I am assuming this question really intends to elicit, is why a mechanism, having a tympanum not less than nine inches in diameter, functioned better in the reproduction of sound than did one less than nine inches in diameter; is that what you are after?

MR. DARBY: No, sir. I think we have covered that subject fully by other evidence. What I am asking this witness specifically is—and I do not want any misunderstanding about it—my specific inquiry is, why? And I want the witness to give every reason he can possibly think of—why nine inches was set out in his patent as the minimum size.

THE COURT: All right.

MR. DARBY: I think I understand your Honor's difficulty, but I cannot help it.

THE COURT: You are entitled to that position.

XQ. 126. Have you advanced every reason now?

A. No, Mr. Darby. I think I would like to augment that by saying that every one was asking then, everyone interested who saw it, including my attorneys, and whether afterwards or before, or when, I do not exactly remember. I am sure that everybody connected with the prosecution in the Patent Office was asking the

very question that his Honor just stated, and I was not——

XQ. 127. Just a minute, Mr. Hopkins. We have passed beyond the question asked by the Court.

XQ. 128. Have you stated everything you want to state, Mr. Hopkins, as to why the size of nine inches is set forth in your patent as the minimum diameter of the tympanum, not only in the specification but in the claims?

A. I had nothing to do with the claims, Mr. Darby.

XQ. 129. You did not, and do not know of any other reason than has been advanced by you on the witness stand here now as to why nine inches was set up as the minimum size?

A. Yes. I told you that below nine inches by careful experiment, we found that the efficiency in the bass ranges was falling off and that we did not believe—that is, nine inches was a rather rough way of putting it—I mean it was a zone there of that size, and below that the basses were not reproduced in what we considered the full amplitude to match the rest of the sound gamut.

XQ. 130. So that in order to get the full amplitude of the sound to match the gap——

A. Not the gap—the gamut.

XQ. 131. You considered a minimum of nine inches essential; is that right?

A. I did not think a minimum was essential, and I am not so sure today that giving any minimum was, and that is just the point I wanted to bring out a few moments ago, but it was so difficult to show people, or to explain to any one what was taking place in that particular element, that would not take place in some small thing that did not do the trick at all; that the easiest way out was to give a minimum below which the public should not make this thing if they expected to get good results.

XQ. 132. I see. You had a great difficulty in ex-ining to people why your cone would do something t a smaller cone would not?

A. I still have.

XQ. 133. All right. Then have you said every-ng now that you care to say as to why the size of ne-inch diameter of tympanum is set forth in your tent as a minimum? I want to get from you every ason that you have.

A. I have not in mind at the moment, but at any ne at all it might arise, that I might want to say re about it.

XQ. 134. No, I would rather have you now.

A. But at the moment I do not think of any reason.

XQ. 135. Well, suppose we take the time right now let you have it, because I want to have you say every-ing you can think of on the subject right now.

A. I am willing to answer any question, but I am t willing to be put in the position of thinking up erything that I might want to say.

XQ. 136. The reason for my putting the question at way, Mr. Hopkins, was because—perhaps I should t say it—I will strike it out. I call your attention page 83 of your testimony in the Western Electric se, the record in the Court of Appeals. You testified follows, didn't you?

"XQ. 213. And when you selected the nine-inch size of your tympanum as the minimum size, that, I assume, was based on your experience in these tests with the phonograph?

"A. That was based on experiments that led up to what we contributed at that time which gives a better result than what was generally known.

"XQ. 214. That is, as applied to the phono-graph art at that time?

"A. Yes, in other words, the ear is the final test, and the human being that owns the ear is going to say whether the thing is good and whether you can sell it, and we could not sell it to them unless they were satisfied.

"Now, we had to arrive at something in that dark age and we did not have very much encouragement from either the Patent Office or anybody else, and it was a mighty difficult proposition and the reason for choosing that size was that we were made to choose it. We did not want to choose it, we were made to choose it by people hollering about a whole lot of little diaphragms that were previously used and did not do this thing.

"Now, we were caused to choose the minimum size. Where there are little diaphragms, which are one thing, and big diaphragms, which are other things, there must be a line of demarcation drawn and we had to draw it, and when we drew it we made that size. We may have cheated ourselves or we may have taken more than was our due."

Was that correct; you testified that way?

A. That sounds right to me except in one particular.

XQ. 137. You testified to that?

A. I think I did. I am not looking at it for a moment——

XQ. 138. I have not asked you a question on it yet.

A. I wish to qualify my answer.

XQ. 139. You wish to change it?

A. No, I do not.

XQ. 140. You wish to qualify it?

A. I want to say that when it said the word "made"——

XQ. 142. Do you want to change or modify that testimony now in this case, Mr. Hopkins?

A. No. I was just about to explain what was ant.

THE COURT: Mr. Darby is giving you an opportunity to do what you were starting to do a minute ago, if you want to.

THE WITNESS: Explain what was meant at that time by that word, your Honor?

THE COURT: Yes, you may add that to your answer, if you so desire, so go ahead.

THE WITNESS: That when I so testified I meant that conditions were such that that was the only way I had of getting out of it without explaining something that I found difficult to explain. I do not mean that I was forced by any proceedings of any kind to give this minimum. It might have gone on forever without being able to explain——

XQ. 143. You certainly do not want to convey e idea that you had been forced by the Patent Office adopt 9 inches, did you?

A. No. I did not want to give the idea that somedy says I must do it. It was simply that in order to fferentiate, we had to arrive at something, and this ing that was already in there, for telling people not make it smaller than that, was as good a way to get t of it as any.

XQ. 144. Mr. Hopkins, let me read you this passge, one sentence, page 83:

"We did not want to choose it, we were made to choose it by people hollering about a whole lot of little diaphragms that were previously used, and did not do this thing."

What people did you mean were hollering about hese little diaphragms?

A. Everybody that wanted a distinction made, one which would do the thing, and the little one that would not.

XQ. 145. And it was furthest from your mind when you testified in this case that it was the Examiner in the Patent Office that was doing this hollering?

A. Amongst other people, the Examiner was one of the people to whom we had to explain this thing, or to differentiate this thing.

XQ. 146. As a matter of fact, he was the only person that you had to differentiate it for, I mean?

A. No, at that time I had a great deal of trouble in explaining what was taking place.

XQ. 147. But the Patent Office was the only one you were trying to get anything from; is that right?

A. At the time we wanted to get a patent. Now I did not prosecute the case——

XQ. 149. I will ask you a question which I think you can answer categorically now, Mr. Hopkins; did not you mean by the testimony that I have just read to you, given by you in the Western Electric case, when you said the 9-inch or that 9 inches was set as the minimum diameter for your tympanum, because you were made to do it by the Examiner in the Patent Office during the prosecution of your patent application?

A. No. I do not know that I was made to do it, or what the Examiner required.

XQ. 150. You mean you do not know it now?

A. No, I do not even know it now, whether the Examiner required any dimensions—made any dimensional requirement whatsoever.

XQ. 151. You have never even reviewed the file wrapper of your patent?

A. No.

XQ. 151a. And having gone through all these litigations and have never reviewed the file wrapper of your application?

A. No. I do not remember having reviewed the file wrapper or I do not remember ever having read the file wrapper at any time.

XQ. 152. And you testified as follows in the Crosley case, didn't you, page 39, second paragraph:

> "As to whether or not the statement in Patent No. 1,271,529—'The base of the central conical portion *l'* of the tympanum should exceed in area one-half of the effective area of the entire tympanum, that is, the area of the aperture in the rims K, K',' is what I meant by my recent testimony—those limitations were put in to distinguish from other things on the ground of size only."

You so testified, didn't you?

A. I think I did.

XQ. 153. And do you want to modify that in any respect?

A. No.

XQ. 154. So that you stand by that testimony in the present case?

A. Unless there is something misleading about it that I did not see at the moment. I am perfectly willing to stand by it.

XQ. 155. You likewise testified in the Crosley case on page 42:

> "When I filed my specification and drawings I was attempting to describe accurately in its minimum dimensions, the very best device that I knew how to make."

Is that correct; did you so testify?

A. I suppose I did, Mr. Darby, but I was trying to—is there anything associated with that statement that would——

XQ. 156. Yes, you can see what it is associated with, referring to bodily movement. Now, Mr. Davis, you might explain to him that the narrative form——

MR. DAVIS: You understand, Mr. Hopkins, that this record has been reduced to narrative form. It is not the exact words that you testified to, but reproduced in narrative form, which is now required by the Courts.

A. I think that is accurate. It might be misleading to say that I was attempting to describe its minimum. I was attempting to describe, and I gave the minimum, which would give the very best device I knew how to make.

XQ. 157. You mentioned celluloid in your patent as one of the elements, possible elements?

A. Yes.

XQ. 158. Is that right?

A. Yes.

XQ. 159. And I think you testified in one of the cases that you read about every bit of printed literature that you could find on the subject in connection with producing this cone device of yours?

A. I think, Mr. Darby, that I said I read everything on the subject of acoustics. I do not ever remember having read anything on the subject of producing cones.

XQ. 160. You read everything, I think your testimony was—I can find it, if necessary—that you read everything on the subject of sound reproduction?

A. Everything that was available around at that time.

XQ. 161. And on reproducing devices?

A. Yes.

XQ. 162. And with your prior experience in the patent profession, I assume that one of the first places

you looked at was in the prior art, the prior patented art; is that right?

A. No. It was not. When I was with Mr. Edison, I was not at all interested in the patented art, and we were more interested in the pure physics.

XQ. 163. The reason I asked that was because I notice that in the earlier Lumiere patent it refers to celluloid as a possible substance, and I was wondering if you read the Lumiere patent before you applied for your patent?

A. I do not remember whether I had read that patent prior to the application, but that was not the reason, Mr. Darby, for the mention of celluloid, because we——

XQ. 164. You are anticipating, Mr. Hopkins. Is celluloid a suitable substance?

A. In a thin sheet, it is possible to use it. It is not very good.

XQ. 165. In your cross-examination, and when you testified on the Western Electric case, on this subject, page 97, you testified:

> "XQ. 281. What are the collodial substances you referred to in your patent No. 1,271,527 at line 66 on page 3, as being suitable for your tympanum?
>
> "A. Paper, fibre, cellulose.
>
> "XQ. 282. Celluloid?
>
> "A. Celluloid is not suitable.
>
> "XQ. 283. Well, is it a collodial substance?
>
> "A. It is a collodial substance."

You so testified, didn't you?

A. I am sure I never heard the word "collodial."

XQ. 166. I presume he meant colloidal. A typographical error; but with colloidal substituted for collodial, I have read it accurately, you so testified, didn't you?

A. I may have.

XQ. 167. You do not question the fact that you did?

A. I did, if there is any question of doubt about it.

XQ. 168. Am I correct in my understanding that you sold your patent to the Lektophone Corporation in return for stock; is that right?

A. Yes.

XQ. 169. And was that a substantial percentage?

A. Yes, I would say so.

XQ. 170. And you still have that percentage?

A. Yes.

XQ. 171. You have never disposed of it?

A. No.

XQ. 172. The Sylo case, you recall, is the first case in which this patent was involved, the one before Judge Campbell?

A. I believe it was.

XQ. 173. I call you attention to the testimony you gave at that time, page 64:

> "XQ. 149. Were you interested in the Lektophone Company at the time?
>
> "A. I do not know whether I was or not. At one time I held an interest in the Lektophone Company which I do not now hold."

You so testified?

A. I think I did.

XQ. 174. You were in error, were you?

A. In some respects, as I remember it then. I was in error because Mr. Davis was taking care of my affairs and I did not know as much about it as he did at that time, and I believe I made several misstatements which were afterwards corrected.

XQ. 175. I see. That testimony given in the case which first went to trial, the record indicates the trial began on November 18, 1925, and in the Western Electric suit, in which the trial began on June 8, 1926, you

were asked the following question on direct examination by Mr. Davis, on page 37:

"Q. 2. What connection have you now with the plaintiff, Lektophone Corporation?

"A. I am a stockholder.

"Q. 3. To what extent?

"A. I believe substantially 5 per cent. I have retained."

You so testified, didn't you?

A. I think I did, yes.

XQ. 176. You were likewise in error on that?

A. I may have been slightly in——

XQ. 177. And the Brandes case was the third case that came up for trial, was it not?

A. I think it was. I do not know whether it was the third or fourth. I am not sure, Mr. Darby.

XQ. 178. In the Crosley case you testified as follows, page 21: "I am a stockholder of the Lektophone Corporation, my stock representing my original interest in the invention." That corresponds with the testimony you have given in this case, does it not?

A. No, I hold a larger interest now than I originally held.

XQ. 179. You have?

A. Yes.

XQ. 180. I rather gained the impression, and perhaps the error was mine, that your present interest in the company was what you acquired by reason of the sale to the company?

A. No, my answer to your question was whether I still had my original interest.

XQ. 181. And what was that original interest?

A. It was somewhere around 5 per cent. I do not remember at the moment.

XQ. 182. Somewhere around 5 per cent.?

A. I think so.

XQ. 183. I call your attention to the testimony that you gave in the Rola case, which I think was the last case. You recall that that was the last case in California?

A. I think it was.

XQ. 184. And that trial was on May 10, 1928, page 113: "My interest in the plaintiff corporation is that I am a stockholder and a licensee. I own part of the stock and I got that for my invention. It is somewhere around 17 per cent." Did you so testify?

A. I think so.

XQ. 185. Which is correct, 17 per cent. or 5 per cent.?

A. Both.

XQ. 186. That you got in return for the invention?

A. For the inventions.

XQ. 187. For the invention of the patent in suit?

A. My interest has been enlarged by the sale of other inventions since.

XQ. 188. You understood my previous question as meaning the invention of the patent in suit, have you not? The remuneration you received for the patent in suit. You say you understood my question in giving your previous answers?

A. Yes, but when you mentioned 16 per cent.——

XQ. 189. 17 per cent.

A. Or 17 per cent., the conditions have changed, because the increase in my holdings has taken place since that time.

XQ. 190. But I call your attention to the fact that in the Rola case you testified: "I own part of the stock and I got that for my invention." What invention were you talking about there?

A. I was probably talking about this one, and if the entire amount of 17 per cent. to which my holdings

had been enlarged was meant then my answer should have been inventions.

XQ. 191. The Lektophone Corporation is not a manufacturing concern, is it?

A. No.

XQ. 192. It is a holding company owning this patent under which it grants licenses to others?

A. Yes.

XQ. 193. And I think that you are connected with a company which is one of the licensees, is that right?

A. Yes. No, I am mistaken there. I am one of the licensees. It is not a company.

XQ. 194. What is the trade name of the brand you make?

A. There was a company called the Titanafram Company which held a Lektophone license with which I was connected. That company I am not longer connected with, but have a license of my own.

XQ. 195. And what was the size of the Titanafram?

A. Various sizes, from twenty-two inches up to five feet.

XQ. 196. As a matter of fact, the minimum size was limited by the license, was it not?

A. Yes.

XQ. 197. What was the minimum size?

A. Twenty-four inches, I believe.

XQ. 198. That is a two-foot diaphragm?

A. No, a two-foot device.

XQ. 199. That twenty-four inches had nothing to do with the tympanum, or the size of the tympanum?

A. The tympanum was the interior part and it was surrounded by sounding boards.

XQ. 200. What I am trying to get at was twenty-four inches the tympanum alone or the tympanum plus the sounding board?

A. The tympanum plus the sounding board.

XQ. 201. About when as near as you can recall did you complete your first structure from which as I understand it the drawings of your patent in suit were made?

A. The drawings of the patent were not made from the first structure, but the structure from which the drawings of the patent were made were completed somewhere about 1911, I believe, but I am not positive about that. 1911 it seems to me——

XQ. 202. Somewhere around there?

A. Yes, somewhere around there.

XQ. 203. And did you show it to Mr. Edison, did you demonstrate it to Mr. Edison?

A. That was not made until quite some time after I had left Mr. Edison.

XQ. 204. Did you ever demonstrate it to Mr. Edison?

A. Not that particular model.

XQ. 205. You had demonstrated one similar to it in so far as the cone structure was concerned?

A. Yes.

XQ. 206. And who else did you demonstrate either one of those to?

A. At the time I demonstrated to Mr. Edison——

XQ. 207. Are you answering my question?

A. I am trying to. There were present a number of people at the Edison laboratory whom I do not remember, but I do remember that Mr. Dyer, the president of the Edison Phonograph Company, was there.

XQ. 208. Mr. Dyer was subsequently the president of the Lektophone Company?

A. Yes, quite some time later.

XQ. 209. And did you try to commercially exploit the device?

A. At that time?

XQ. 210. Yes, any time subsequent to 1910. I would like to have you recite in their order as near as

you can recall everybody that you tried to get interested in this device and demonstrated to them for that purpose?

A. I got Mr. Davis and Mr. Pennie, I got Mr. Pennie interested and then later Mr. Davis and they handled the exploitation proposition for me from then on.

XQ. 211. But you demonstrated it to the Victor, did you not?

A. That was at a time——

XQ. 212. They kept you advised as to who they were demonstrating it to?

A. I went with Mr. Davis.

XQ. 213. And did the Victor people take it up?

A. They had a board of directors' meeting.

XQ. 214. But they did not actually take it up?

A. They considered it——

XQ. 215. Pardon my interruption, Mr. Hopkins?

A. No, they did not take it up.

XQ. 216. Do you know of any other large concerns that you demonstrated it to for the purpose of having them take it up?

A. I am afraid you will have to get the information from Mr. Davis or some of the other members who had that in charge.

XQ. 217. They did not keep you advised as to what was going on?

A. They may have, but my memory does not tell me just what was going on then, because I was not directly connected with it.

XQ. 218. Your memory is faulty in that respect?

A. I would not want to depend on it.

XQ. 219. Can you tell me in general whether or not it is your recollection that effort was made, more or less continuous effort was made, to interest somebody in it?

A. I am quite sure there was.

XQ. 220. And when is the first time that it was actually taken up and incorporated in a commercial structure?

A. The Pathe Company incorporated it in a commercial structure that I became familiar with. I think it might have been before that time, there might have been——

XQ. 221. When did the Pathe people take it up?

A. I cannot tell you.

XQ. 222. You do not know the approximate time?

A. I do not remember those dates.

XQ. 223. Roughly, was it in 1913?

A. I am sure I would hate to try and place it. I have not kept track of those particular dates.

XQ. 224. And your personal connection with the exploitation of the device was severed, I gather from your statement, and you left it entirely in the hands of Mr. Pennie and his firm; is that right?

A. Yes. I engaged in another endeavor at that time——

XQ. 225. You went to work for the Eastman Kodak Company in Rochester?

A. Yes.

XQ. 226. And the next work that you did in connection with this matter was in connection with the Pathe Actuelle?

A. Yes, I think it was at the Pathe factory.

XQ. 227. And you know Mr. Lewis, don't you?

A. Mr. Lewis at the Pathe factory?

XQ. 228. Yes, Frank Lewis.

A. Yes.

XQ. 229. And in what capacity was he employed there?

A. I do not know exactly what his title was but he was the engineer that seemed to be in charge of the designing.

XQ. 230. And you went to work for the Pathe people under Mr. Lewis?

A. No, I was only there to do——

XQ. 231. A special job?

A. A special job.

XQ. 232. They were having some trouble and they wanted to get you to help them out of it?

A. No, I would not say that was it.

XQ. 233. They were having difficulties with this Pathe Actuelle and they employed you because of your knowledge and experience in the art to see if you could help them?

A. With a view of improving it.

XQ. 234. And who was the one who took up with you the question of securing your services with the Pathe people?

A. I do not remember that.

XQ. 235. And perhaps you were not under Mr. Lewis but Mr. Lewis is the man that you came in contact with?

A. He was the man there at that time.

XQ. 236. What was the nature of the trouble that they were having, do you recall?

A. I think at that time that you speak of it had to do with the transmission line to the diaphragm.

XQ. 237. They were having quite a little trouble with the needle digging into the record, don't you recall that?

A. No.

XQ. 238. How long did you stay with the Pathe people?

A. At that time?

XQ. 239. Yes.

A. I do not believe that I was there off and on maybe a month; I was not there continuously at any time.

XQ. 240. Would you dispute the fact that you were there off and on approximately two months?

A. No, it might have been.

XQ. 241. And while you were there, do you recall whether or not the Pathe people had a standard form of card that they sent out to their customers who had purchased Pathe Actuelles?

A. I never heard of such a thing.

XQ. 242. And you did not see such a card and Mr. Lewis did not show you any such card?

A. I do not believe he did. I do not remember it.

XQ. 243. Made out in a form to indicate, and maybe this will refresh your recollection, made out to be sent to customers who complained about the Actuelle so that they could point out on the card the nature of the trouble?

A. Never heard of it before.

XQ. 244. Or any card of that nature?

A. Not within my memory.

XQ. 245. And you have no recollection of Mr. Lewis showing you such a card?

A. None whatever.

XQ. 246. Then at the end of a month or two, or two months, you severed your connection with the Pathe Company, is that right?

A. I did not have any connection with them other than going there to do that special work.

XQ. 247. You got paid for it?

A. And it lasted, it might have lasted a month or six weeks or two months. At the present time I am unable to say.

XQ. 248. You got paid for it did you not?

A. Yes.

XQ. 249. $50 a week?

A. It may have been. I do not remember what it was. There were just some charges that I made.

XQ. 251. Did Mr. Lewis after you severed your nection with the Pathe Company, show you, if you recall, a metal frame with a specially designed unit t he had gotten up as a loud speaker; do you re- l that?

A. No, I do not.

XQ. 252. Do you recall that after that time you re experimenting with a horn for use in connection h a loud speaker?

A. Oh, yes, after that lots of horns since then.

XQ. 253. In developing a loud speaker for radio, s it not?

A. Well, the horn that I think you are speaking out was used for radio. It was never a commer- al device. I mean it was not a manufactured device.

XQ. 254. But you were experimenting with a horn r that purpose?

A. I was experimenting with a very large type f horn.

XQ. 255. You also testified in the Brandes suit, d you not, Mr. Hopkins?

A. Yes, sir.

XQ. 256. I show you Defendant's Exhibit C for dentification, did you examine a structure similar to is in that case?

A. Yes.

XQ. 257. And you testified concerning it?

A. Yes.

XQ. 258. I call your attention to the testimony in e cross-examination concerning the rubber rim in e Brandes device. It is at page 174:

"RXQ. 278. But so far as it stored as flexure of the rubber it would have the effect of the spring?

"A. Exactly.

"RXQ. 279. And the energy being returned from the storage would tend to help the reversal of the movement of the cone?

"A. Yes, sir.

"RXQ. 280. Exactly like Mr. Scull's spring?

"A. Yes, sir.

"RXQ. 281. Now, when you fastened the outer edge of that rubber to the ring so that it has to stand still, you got more of an abutment?

"A. Yes, that aids it clear out.

"RXQ. 282. And consequently you have one edge of the rim standing still while the other edge moves?

"A. Yes.

"RXQ. 283. And the rubber in between acts as a spring?

"A. Yes.

"RXQ. 284. My understanding of your statements is that they are all predicated on the idea that the rubber which we use is elastic.

"A. I should hope so.

"RXQ. 285. Do you mean to say that it has the property of elasticity?

"A. It has.

"RXQ. 286. And you think it has elasticity in the form in which we have it there?

"A. Yes, sir."

You so testified, did you not, Mr. Hopkins?

A. Yes.

XQ. 259. You do not want to change that testimony now, do you?

A. No.

XQ. 260. Mr. Hopkins, I will read to you the testimony that you gave in question and answer form in the Crosley record, page 80:

"XQ. 86. In connection with the Edison work I understand that you are absolutely sold on the size, shape, and mounting construction of those diaphragms, and also on the material, that paper, for the use of the diaphragm?

"A. Well, I would not say that. The size would probably never have been talked about much if it had not been for the fact that we had an existing standard of the sound box and horn in those days and no matter how much you improved the quality, if you could not get the volume that the phonograph made, then you were not in the running and you had not made an improvement. Now, there was another reason for size having anything to do with it at all. In the sound box we had a diaphragm held at the edges and many forms of diaphragms in sound boxes. Some of them are rounded up, some of these are coned up and some of them look very much like these only they were small and operated on a confined body in the sound box. Of course, looking at it now it would look differently but we figured we had to differentiate from the small diaphragm used in a sound box and in the Patent Office it was necessary to get away from that.

"XQ. 87. To do what?

"A. It was necessary to get away from having the big diaphragm which had the characteristically new way of working from a diaphragm that looked just like it but was small and worked in the sound box against a confined body of air."

You so testified?

A. Yes.

XQ. 261. And do you wish to change that or modify it?

A. No.

XQ. 262. And in the Brandes case, page 58, you testified as follows:

"XQ. 203. No, please do not argue with me. I will try to ask the question as briefly as I can and you answer as briefly as you can and we will get along faster. Now this wrinkling is due to what, in relation to the width of the rubber from the edge of the mouth to the edge of the cone? Why is it wrinkled? Is it because it is under a tension or because it is slack?"

He was referring, you will recall, to the rubber rim of the Brandes cone.

"A. Because it is flabby.

"XQ. 204. Is it because it is tensioned or because it is slack?

"A. It is because it is slack in places, some places more than others.

"XQ. 205. Is it not slack entirely around P-6?

"A. It is not slack over there.

"XQ. 206. To what extent?

"A. About an inch.

"XQ. 207. At any other place where you find that it is not slack?

"A. It is not slack up there."

You were pointing out, were you not, various portions in the periphery in the Brandes cone that you had under inspection, places where the rubber was not slack?

A. Yes.

"XQ. 208. To what extent is this last lack of slackness, over how much of the circumference?

"A. It seems to be pulled down to the cone at that point in a vertical zone about one-quarter of an inch wide.

"XQ. 209. At the top and bottom the slackness is quite pronounced?

"A. It seems to be immediately at the top and at the bottom. At another point it is pulled down."

You pointed to a still different point again on the cone, do you recall?

A. I think so.

XQ. 264. You so testified in that case, did you not?

A. I did.

XQ. 265. And the testimony that I read correctly refers to the Brandes cone that you had under consideration?

A. Yes.

XQ. 266. And of course a thin piece of rubber is more readily vibrated if it is under a tension than if it is wrinkled up, slack, is it not, as a matter of acoustics?

A. I do not see what a thin piece of rubber has to do with acoustics.

XQ. 267. Will you answer my question?

A. I do not know. I do not know whether it is more readily vibrated. Did I understand you to say that it was more readily vibrated if it is tight?

XQ. 268. Yes, than if it was just slack and flabby.

A. That question is kind of difficult. I imagine it may be.

XQ. 269. You were unable to tell me a little while ago as to when the Pathe people first came on the commercial market?

MR. DAVIS: I can give that date if all that Mr. Darby wants is the date.

MR. DARBY: Mr. Hopkins gave the date in the testimony of the Western Electric Company from

a written record, the last quarter of 1918. Is that correct?

MR. DAVIS: Yes.

By MR. DARBY:

XQ. 270. And you did not design the cone used by the Pathe people, did you?

A. No, sir.

XQ. 271. On the question of confined air, I call your attention to the testimony you gave in the Sylo case, page 54. You stated as part of your answer to Q. 75:

> "If you have got any confined body of air or semi-confined body of air present in the loud speaker anywhere, you are going right back to the horn that we talked about yesterday."

That was your testimony, was it not?

A. I think so.

XQ. 272. And you do not want to change or modify that?

A. No.

XQ. 273. And the horn that you spoke about "yesterday," as referred to in the testimony I read you, referred to the sound box horn construction with the phonograph?

A. Sound box and horn.

XQ. 274. And in the Western Electric case, referring to the same subject, you stated, middle of page 40:

> "In other words I could not carry beyond that point, beyond the distorted point and get a satisfactory result until I finally came to the conclusion that it was the confined character of the air in this system that was responsible for it, and I made up my mind that the high pressure necessarily produced in the sound box and let loose in the throat of the horn were responsible for it altogether, with

the necessity for using the horn as a transformer to let down these pressures."

You so testified?

A. I think so.

XQ. 275. And you were testifying concerning the disadvantages of sound box and horn structures?

A. Yes, the things that produce resonances.

XQ. 276. And you do not desire to change or modify that testimony, do you?

A. No.

XQ. 277. Again on page 75 of the Western Electric record:

"XQ. 163. I understand from your testimony, in your patent, that in the old sound box art of which this Exhibit 6 is a sample, the air was confined between the diaphragm and the back of the sound box?

"A. That depends entirely on how big a hole there is in the sound box, how much space there is where the air is so confined.

"XQ. 164. In other words, when in your patent you refer to the confined air there, you use that in the relative sense, I assume?

"A. Oh, well, I use it in the fact that there is an enclosure in which the air that is being operated on is surrounded by walls.

"XQ. 165. And my understanding of the operation of a sound box of this sort is that the air in that enclosure is continually moving in and out of the opening at the back of the surface?

"A. Well, that is questionable, how much it moves in and out; it may act just as a cushion, the part that is near the hole and the edge is more likely to act as a cushion. There is probably very little movement in and out of that hole."

Is that your testimony in that case?

A. Yes.

XQ. 278. And you see no reason to change it now?

A. No.

XQ. 279. Then on the question of bodily movement you stated at page 87, in answer to XQ. 236:

"At that time in those dark ages before we went into the refined experiment, which, by the way, did not lead very far in this art, it did not matter. We discovered the remarkable result that you could get from a cone mounted in this way; now, apparently to your hand that part which you held in your hand of that thing, it will move bodily. That was what was meant by the use of the word 'bodily.'

"XQ. 237. And your idea at that time was that you were constructing this cone so that it would be so rigid that it would not have these waves in it; was that not right?

"A. So that it would not have an obvious breaking up, which would happen if you made the thing too flimsy.

"XQ. 238. Are you trying in your testimony here to change the statement in your specification; I am reading from page——

"A. No, I am trying to tell you what it meant at that time.

"XQ. 239. Yes, all right, let me finish. I call your attention to the statement on page 2, line 112, where you said that: 'The conical shape is given the tympanum so that the shock or vibration impressed upon the apex of the cone in a direction toward the base will move the whole cone bodily, the strain being imparted edgewise of the material and no wave motions being set up in the thin material of the cone——'

"A. Yes.

"XQ. 240. (Continuing.) —'the curvature of the walls of the cone precludes the setting up of waves in the material, and the intended object, a simultaneous movement of the whole conical portion of the tympanum, is best attained.'

"Now do I understand from your testimony that you are trying to change that statement?

"A. No.

"XQ. 241. You agree with it still?

"A. Yes. I was just trying to tell you what it meant, the use of those particular words meant, at that time, why we used those words. You have to use something to express yourself.

"XQ. 242."

MR. DAVIS: I think you ought to put in what the witness said.

XQ. 280.

"MR. SCULL: Well, some of you use a lot of words to do that.

"THE WITNESS: I know, in this art especially, but that was the best we could do at the time.

"XQ. 242. When did you commence to get the idea that this language about the bodily movement of the cone did not mean the same thing today as it did back in 1913?

"A. Why, after people infringed us and began to tell us about it."

Do you recall testifying about that?

A. Yes.

XQ. 281. Do you desire to change your testimony now in any way?

A. No.

"XQ. 243. In other words, when you commenced a study of the so-called infringements, then you began to perceive that this language did not apply to your invention; is that right?

"A. No, the other people were trying to tell us that that language did not mean what we said it did; that is the first time that I ever paid much attention to it, if that is your question.

"XQ. 244. I call your attention to the fact that in a patent granted to Marcus C. Hopkins, No. 1,390,206, which was filed June 7, 1920, and granted September 16, 1921, you—and I assume that you are the Marcus C. Hopkins of that patent——

"A. May I see the patent? Yes, I think I read that.

"XQ. 245. That shows what I presume to be an 'Actuelle' diaphragm; is that correct?

"A. Yes.

"XQ. 246. And you stated 'that the vibrations to which the transmission element is subjected are exerted upon the diaphragm, which is thereby caused to vibrate piston fashion——'

"A. Yes.

"XQ. 247. Is that correct?

"A. Yes.

"XQ. 248. And that meant bodily movement, did it not?

"A. No, it meant piston fashion.

"XQ. 249. Does a piston vibrate in any other way than bodily?

"A. Some pistons move as a diaphragm in flex, and some pistons move bodily or wholly, I should say, forward and back.

"XQ. You are an engineer, are you not, Mr. Hopkins?

"A. In a way.

"XQ. 251. If anybody described to you a piston——

"A. Yes.

"XQ. 252. Would you think of a diaphragm clamped on its edge?

"A. No.

"XQ. 253. You meant one that would be free, that could move bodily, like a piston in a steam cylinder?

"A. Yes, but I would not think for a minute that I meant by bodily that there was no bending at all, even in the case of an iron piston that moved up and down in a cylinder. If I understand you, and I want to answer your question correctly, there is a giving at the edges; is that what you mean? So that the whole thing can be moved, or it looks as if it is all moving at once?

"XQ. 254. I do not know what structure you are talking about now——

"A. Well, it was that asking whether that diaphragm moved in that way?

"XQ. 255. That diaphragm, meaning the diaphragm of the Patent No. 1,390,206 which I showed you?

"A. Yes."

XQ. 282. You so testified to that effect?

A. I think so.

XQ. 283. And you do not desire to modify or change that testimony in any way?

A. I do not see any reason to, no.

XQ. 283a. And on page 40 of the record on appeal in the Crosley case appears the following, with reference to the sand patterns; I believe you stated:

"The nodes and loops are not effective playing waves; they are not only not effective, but they

are destructive in producing tones and signals not applied t[illegible]pex."

You so testified?

A. Yes.

XQ. 285. And that is your testimony here?

A. Yes.

XQ. 286. You have no desire to change or modify it?

A. No.

MR. DAVIS: May it appear that the testimony had to do with the circular waves? The sentence immediately before says——

MR. DARBY: Yes, I will make it perfectly clear and put that in, if you desire, Mr. Davis, making the entire question read as follows:

"These circular waves while we did not describe them in whole, we allowed the terms to be expressed in the terms moving the cone bodily and really the effective playing waves, the nodes and loops are not effective plain waves; they are not only not effective, but destructive in producing tones and signals not applied to the apex."

Do you desire to change that?

A. I do not see any reason for modifying it. It is a little bit involved, but it seems to me to mean what I was trying to say.

XQ. 287. You are the patentee named in this Canadian Patent No. 266,936, granted December 21, 1926, on an application filed March 9, 1926, are you not?

A. Yes.

XQ. 288. And you are likewise the patentee of Canadian Patent No. 266,934, granted December 21, 1926, on an application filed March 9, 1926, are you not?

A. Yes.

XQ. 289. And the statements contained in the specifications of that patent are true to the best of your knowledge and belief at the time you executed the oath for them?

A. I think so, yes.

(Patent No. 266,936 to Hopkins received in evidence and marked "Defendant's Exhibit No. 43.")

(Patent No. 266,934 to Hopkins received in evidence and marked "Defendant's Exhibit No. 44.")

RE-DIRECT EXAMINATION.

RDQ. 290. Mr. Hopkins, in the testimony that was read last by Mr. Darby from the Crosley case, in which you said it was somewhat involved, reference was made to nodes and loops which you said there was not effective plain waves; can you tell us what nodes and loops were referred to, and tell us in the language that has been used in this trial, so as to identify them?

A. They are the nodes and loops made by the circumferential wave.

RDQ. 291. That is, the radial nodes?

A. Which go around and make what has been called——

RDQ. 291a. The radial nodes?

A. They make radial nodes, yes, but those vibrations have been called——

THE COURT: Parasitical waves?

THE WITNESS: Parasitic; yes, sir.

RDQ. 292. And the circular waves which you referred to in the Crosley testimony, and which you called the really effective playing waves, will you identify them in the language that we have used here?

A. That is the flexures produces by the application of the energy at the apex of the cone that is produced by the time element as a run down the cone towards the circumference.

RDQ. 293. And that has been referred to in this case as radial waves?

A. Yes.

RDQ. 294. With circular nodes?

A. Yes, radial waves, because they run in a radial direction.

RDQ. 295. Put your mind for a minute on this license that you have from the Lektophone Corporation. You have a license from the Lektophone Corporation under the patent here in suit; is that right?

A. Yes.

RDQ. 296. Is that license limited in the size of the device that you can build under it?

A. No.

RDQ. 297. And you have some other license, have you, which refers to a twenty-four-inch limit?

A. Yes; that is a license from another company on another invention, a later development, which is based upon the invention. In other words, the subject of the invention in suit.

RDQ. 298. That is the second license is under one of your patents for a later invention but from another company?

A. Yes.

RDQ. 299. And in that license how does the 24-inch limit come in?

THE COURT: That license is from the Lektophone Corporation, is it not?

THE WITNESS: No.

THE COURT: I thought it was the license from the Lektophone to a company in which you were interested and had a personal license, but it was

from another company to a company in which you have some interest?

THE WITNESS: I have a Lektophone license, and then I have another license to another invention.

THE COURT: You personally have?

THE WITNESS: Yes.

MR. DAVIS: May I state the whole situation, your Honor, and make it clear?

THE COURT: Yes.

MR. DAVIS: Mr. Darby, in his cross-examination, brought out this matter of twenty-four inches.

THE COURT: Yes.

MR. DAVIS: And the record will show, I think, that Mr. Hopkins said he had a license from Lektophone that restricted him to making things under twenty-four inches. I understood that Mr. Hopkins had an unlimited license, and the company in which he was interested, had a license to manufacture devices having a diameter an over-all diameter of not less than twenty-four inches. The thing is very much confused. Is there any objection to my stating the facts?

MR. DARBY: None at all. I would like to have them stated.

MR. DAVIS: The facts are these. There was a license granted by Lektophone under all its patents to this Titanafram Corporation. During his connection with that Titanafram Corporation, Mr. Hopkins made some other inventions which he assigned to another company. Those inventions had to do with this so-called Titanafram which was a

titanic loud speaker of this cone type. Then subsequently the Titanafram Corporation was sold out and this license was given from Lektophone to Hopkins personally. Then Hopkins got from this other company to whom he had assigned this second invention, an exclusive license under the second invention, for all sizes over twenty-four inches in diameter, so as to protect him in his Titanafram, which was a large device.

THE COURT: All right, Mr. Darby?

MR. DARBY: Yes, sir.

THE COURT: Does that correspond with the facts, Mr. Hopkins, as you understand them?

THE WITNESS: Yes, sir.

THE COURT: All right.

RDQ. 299a. Now, Mr. Hopkins, I direct your attention to the specification of your patent, No. 1,271,529, where it says that if satisfactory regeneration of sounds are to be had, the whole diameter of the tympanum should exceed nine inches and that the base of the central conical portion should exceed in area one-half the effective area of the entire tympanum; and I ask you to tell us what technical reason there was, if any, for putting that statement in the patent?

A. The technical reason was to advise the public not to make the diaphragm any smaller than that minimum thing, or it would not cover the musical range.

RDQ. 300. No. I do not think you understand me, Mr. Hopkins. I want to know why it would not cover the musical range unless it was made of that size?

A. Unless you made it that—unless you made it that size, it would not play efficiently the proper quantity of bass to go with the other frequencies to complete the gamut.

RDQ. 301. And you had determined that by your periments?

A. Yes. By a long series of experiments.

RDQ. 302. Mr. Hopkins, in order that we may re something concrete to think about, when you con- ve of a tympanum made according to the patent, which the over-all diameter of the tympanum is nine hes, and in which the basal diameter of the cone oc- pies half the area, that is, the basal diameter being 6 inches—now, have that in mind, and tell me what fect it would have, according to your experience, if, ther things being equal, you reduced the size of that ire structure; that is, what acoustical effect would have?

A. I think I can answer that, just as I answered a oment ago. We had discovered by experiments that rthing smaller than, roughly this minimum size of e structure that we gave in the specification, would t play the bass end of the sound spectrum of a sical range that we were after——

RDQ. 303. Do you think that is still true?

A. Yes. I think now we could express it very ch better and I think I could probably clarify the rmation by explaining more plainly how this thing rks, but I do not know that that is what you are ask- g me.

RDQ. 304. I would like to have you do it, but I uld like to have you answer a few questions first, so at we can cover the whole thing at once. I ask you st do you still think that as a matter of acoustics one smaller than that is too small to effectively re- oduce the entire gamut of the sounds?

A. Yes, I do. Of course, that limit was just an bitrary limit, it is a little one side or the other, but still believe that that is substantially correct, as near s you can expect it.

THE COURT: I would like to know whether h means arbitrary limit or whether he used the wor "arbitrary" not meaning arbitrary, or whether he has given it its usual meaning?

THE WITNESS: It is not critical.

By THE COURT:

Q. 305. But is it one of degree only? Do not answer that hastily. Is there a point at or approximately at nine inches where the operation of the device changes?

A. It is the point where the effective combinatio of the bass waves becomes noticeable in falling off.

Q. 306. I am wondering whether you could hav made that ten inches instead of nine, whether it would have been equally true at ten inches as it is at nine?

A. I do not think that if you made it ten inches I do not think it would have been near enough th minimum limit. I think nine inches was about as clos as we could get in inches.

Q. 307. In order that the public might have som guide, you saw fit to mention it in size rather than i complicated terms of function or terms of complicated function?

A. I did not have the terms within my ability. I doubt if I have got them yet.

By MR. DAVIS:

RDQ. 308. Mr. Hopkins, still thinking of th structure in which the over-all diameter is nine inche and the cone occupies half the area, and thinking of i made of paper, what would be the effect of reducin the width of the rim and so the over-all diameter, bu retaining the same 6.36 diameter of cone base?

A. As I said in the patent, if you put concentri corrugations in the rim you can increase the resilienc

narrower rim and of course that would reduce over-all diameter of that same machine.

RDQ. 309. Suppose you made the rim of a more ble material?

A. Then the reduction would depend upon the sible narrowing of that rim by using more flexible erial.

RDQ. 310. Then you would still have the conical a the same?

A. Yes.

RDQ. 311. In other words, am I right, if you intain the same conical area and substitute for the per rim a rim of more flexible material, you can use en a narrower rim of the more flexible material and t the same acoustical effect?

A. And make a close approximation to the same sult.

RDQ. 312. Mr. Hopkins, when Mr. Darby was king you a question, I think it was about Mr. Edi-n's laboratory, he interrupted you. If you have rything you wanted to say about it that you think important here, go ahead and say it. If you do t think it is important, please do not say it.

A. I am not sure just what you mean by Mr. Edi-n's laboratory. I do not remember just exactly what was. I have something I would like to say to the urt.

THE COURT: All right.

THE WITNESS: I would like to explain to your Honor, and this is technical, and it has been gleaned since those early days, in the early days—this has nothing to do with the patent——

MR. DARBY: I object.

MR. DAVIS: I think Mr. Hopkins means there is nothing said about it in the patent specification.

THE COURT: Do you mean it has something to do with the functioning of the device described in the patent?

THE WITNESS: Yes.

THE COURT: All right.

THE WITNESS: And particularly with the first element of the cone. In the testimony I think it will be found that when we began to use the cone as an engineering device to get stiffness, we found an unexepected result. In other words, that cone worked better than what would be expected of a thing that had stiffness.

THE COURT: In that form?

THE WITNESS: Or in any form. It was better than we ever expected it to work. Unquestionably it had a mode of operation different from what we expected and it was that thing working with that mode of operation that we combined with a support and a means for suppressing some of its objectionable features.

Putting the paper, which was a vibratile material, and if it was vibratile it could bend, and a lot of stresses on it, the fact that a thing is moving all at once is quite impossible, but surely a thing that is made out of vibratile material, if you smack it on the end it will take a little time for the energy to run down to the other end, and in running down it cannot help but make a wave, but unfortunately it also bends and sets up these parasitic waves as Messrs. Starling & Cole found out. Probably it was prior to my time and I did not know about it at the time.

A bodily movement of the cone—of course there are times when you put a lot of energy on it, when you move the cone from place to place

even an effective sized cone can be moved from place to place and get bodily movement.

THE COURT: I do not understand that.

THE WITNESS: If you apply enough energy the whole cone will move bodily. We always termed the application of the power as bodily movement before we got into the legal phase of the thing. We call this bodily movement and we called the wave motion as an impression on the air, and unconsciously we always used those terms.

That did not mean that there was not any wave motion in vibratile material when you hit it on the apex. There must be. It precludes any such conception of that term.

Really, looking at it theoretically, if we had a cone that moved bodily it did not have a bit of resiliency in it and therefore it did not have the ability to have waves set up in it. If we had such a cone and we reciprocated it and it was applied on its surface, its movement was impressed on the air to make sound waves. Every square inch of that cone would impress the same amount of energy onto the air.

At the same time that is not true. All of the energy is applied at the apex. It must flow to the outer edge and as the energy flows it is really a bend or wave in the cone running from the apex down to the edge. It goes in a wave and there is a time element in it.

Because it goes in a wave and its energy is being damped off all the time by the energy flowing down to the edge, because it goes in a wave, it can let off any amount of energy that happens to be there. If you have a very high vibration it will be damped off right near the apex. It does

not need much area to damp that off, and the energy is expired.

The energy in the bass notes requires a large area. That continues in the paper in the form of a wave down towards the edge and gets the movement of the whole cone encountered so that it is damped off into a large area there.

The development of musical instruments shows very prettily what is necessary. You take a definite amount of energy available, a fellow blowing a horn, if he is blowing in the upper ranges he will blow on a little cornet with a horn that big. It has been developed by practice, and they found that he can blow all the energy on the air that he can, but if you go into the low ranges he has a horn as big as that (indicating) and he has only got the same amount of energy to blow it with. But he has got to put it on a large body of air in order to get the loudness of that energy at that low frequency. The air does not take a little frequency wave from a small surface.

The "Leviathan" whistle is not the size of a policeman's whistle. The policeman's whistle is not of the same frequency——

MR. DARBY: I do not know just exactly what place this statement, or argument, or what you want to call it—it is a voluntary statement of the witness, which is the proper name for it—will have in the record or in the case.

THE COURT: It is a voluntary statement on behalf of the patentee.

MR. DARBY: But it is not in response to any question.

THE COURT: No. Is it your desire that it be stricken from the record, is that your motion?

MR. DARBY: Yes, sir. I think we are going pretty far afield. I assume Mr. Davis has covered all the ground by proper questions that he intended to cover.

THE COURT: What have you to say, Mr. Davis? This is re-experting.

MR. DAVIS: What I have to say about it is this. Mr. Hopkins was asked by me, ineffectively I am sure, to say what was the relation of size to this discussion. I am conscious of not having directed my questions in such a way as to bring out what he really had in his mind.

THE COURT: You consider that as a supplementary or further answer to that question?

MR. DAVIS: Yes.

THE COURT: That gives it a legal status.

RE-CROSS-EXAMINATION.

By MR. DARBY:

RXQ. 313. You stated that using this cone you obtained unexpected results. What was unexpected about it?

A. It was far more efficient over the whole range especially the lower end of the range than I believed we had a right to expect from the structure.

RXQ. 314. Then its efficiency over the audible range is the unexpected result that you obtained?

A. Yes.

THE COURT: Over a wider audible range?

MR. DARBY: Over the audible range. I made it as broad as possible.

RXQ. 315. And were you familiar with prior use of paper cones?

A. No, not at the time I did this work.

RXQ. 316. How do you know that Starling and Cole found flexing? Is there anything in their article about it?

A. Yes.

RXQ. 317. Where?

A. In the article.

RXQ. 318. Point it out to me.

A. I will try to find it for you. I will have to look that up and I do not want to waste time.

RXQ. 319. It will only take you a minute, and I do not think you will find anything in there about it, Mr. Hopkins.

A. In this article they say that they make it flutter and make the extraneous noises. Is that what you meant by your question?

RXQ. 321. Is a nine-inch cone better than an eight-inch cone?

A. Are you speaking of a nine-inch tympanum?

RXQ. 322. Yes, a nine-inch tympanum.

A. I think it is better.

RXQ. 323. Is it better than an 8½-inch tympanum?

A. I think it is.

RXQ. 324. Is an 8½-inch tympanum better than an 8-inch tympanum?

A. It is, yes.

RXQ. 325. Is the eight-inch better than the seven-inch?

A. Yes.

RXQ. 326. Seven-inch better than a six-inch?

A. Yes, and all the way up.

RXQ. 327. All the way down. I am going down.

A. You are going up in the high frequencies. It is cutting off the basses all the time.

RXQ. 328. And the ten-inch is better than the nine-inch?

A. Yes.

RXQ. 329. And eleven-inch better than ten-inch?

A. Yes.

RXQ. 330. And the twelve-inch better than the eleven-inch?

A. Yes.

RXQ. 331. And so on all the way down?

A. I do not know what you mean by down. I will say up to about 17 when it goes the other way.

RXQ. 332. I tried to use your own terminology. And as you increase the size, each increase in the size of the tympanum makes a better loud speaker than the one one inch smaller?

A. Up until about 17 inches when it goes the other way.

RXQ. 333. Up to 17 inches?

A. Yes.

RXQ. 334. Consequently where is there a critical change, or is there a critical change?

THE COURT: Other than at 17 inches.

MR. DARBY: Other than at 17 inches, yes.

A. There is not any critical change anywhere.

By THE COURT:

Q. 335. Even at 17 inches?

A. At 17 inches, your Honor, it has been improving all the time in volume. At 17 inches we find that we have not had any material that will go with that that will not get lacking in stiffness without getting too heavy over 17 inches. I am only speaking now of the results of actual experiment that we have not found what we would call real improvement above 17 inches.

THE COURT: Is it your understanding at this time that there is no critical size; that 9 inches might as well have been 10 or 9½ or 8 or 7½?

THE WITNESS: No. Down the other way, I do not mean to convey that idea.

MR. DAVIS: What he said, if your Honor please, as I understand it, is, in his opinion, and we are talking about the tympanum now, and I assume that the question implied that you were reducing the thing as you would reduce it for the photographic apparatus over-all——

MR. DARBY: Yes.

MR. DAVIS: Mr. Hopkins said that if you reduced the whole thing to 8 inches, it would lose the basses progressively as it went down in size.

THE WITNESS: I was asked whether a bigger one was better than a smaller one.

MR. DAVIS: Yes and he thought it was, and he thought it got better it went up in size until it got to about 17 inches; did that mean over-all 17 inches?

THE WITNESS: Yes, around 17 inches; it is not critical.

MR. DAVIS: Up above 17 inches over-all, there was no further improvement.

THE COURT: I am lost, Mr. Davis, for a minute. I thought awhile ago, although the witness did use the term that it was an arbitrary size, I thought that another time he said there was the change, or marked difference there, that was otherwise than one of degree, namely, a 9-inch tympanum.

THE WITNESS: Quality.

THE COURT: But the quality, as I understand now, changes there only by degree, and that there is an increase of bass, a great deal of increase of bass that makes no marked change at 9 inches but that runs all

the way up from 3 inches to 17, without any marked change in bass, save that of degree.

MR. DAVIS: May I say what I think the witness actually said?

THE COURT: All right.

MR. DARBY: Is there any question about what the witness actually said?

THE COURT: No, there is not.

MR. DARBY: All right.

THE COURT: So I think Mr. Darby is right unless the case is rested on both sides.

MR. DAVIS: I would like to have an opportunity to answer your Honor's suggestion, but not in the presence of the witness.

THE COURT: Are you through with the witness on both sides?

MR. DARBY: I am through if Mr. Davis is.

MR. DAVIS: I have something.

THE COURT: Then do not let me disturb you.

MR. DAVIS: The only thing I wanted to ask Mr. Hopkins was, whether the sizes that he had mentioned contemplated the reduction of all the dimensions of every part, or an increase of the dimensions of every part, and it is understood he did mean that.

THE COURT: Yes.

STIPULATION AS TO CONDENSED RECORD.

(Filed March 4, 1930.)

And now, to-wit, this twenty-eighth day of February, A. D. 1930, it is stipulated by and between counsel for the respective parties to the above entitled cause, subject to the approval of the court, that the foregoing transcript of record of proceedings at the trial of said cause, in condensed form, the testimony of witnesses being stated only in narrative form, save that in preparing said record the part of the testimony desired by the respective parties to be reproduced in the exact words of the witnesses has been left in question and answer form, shall be treated and considered as the record of the trial of said cause, in making up the transcript of record on appeal.

(Sgd.) PENNIE, DAVIS, MARVIN & EDMONDS,
Solicitors for Plaintiff.

(Sgd.) SAMUEL E. DARBY, JR.,
Solicitor for Defendant.

ORDER APPROVING CONDENSED RECORD.

(Filed March 4, 1930.)

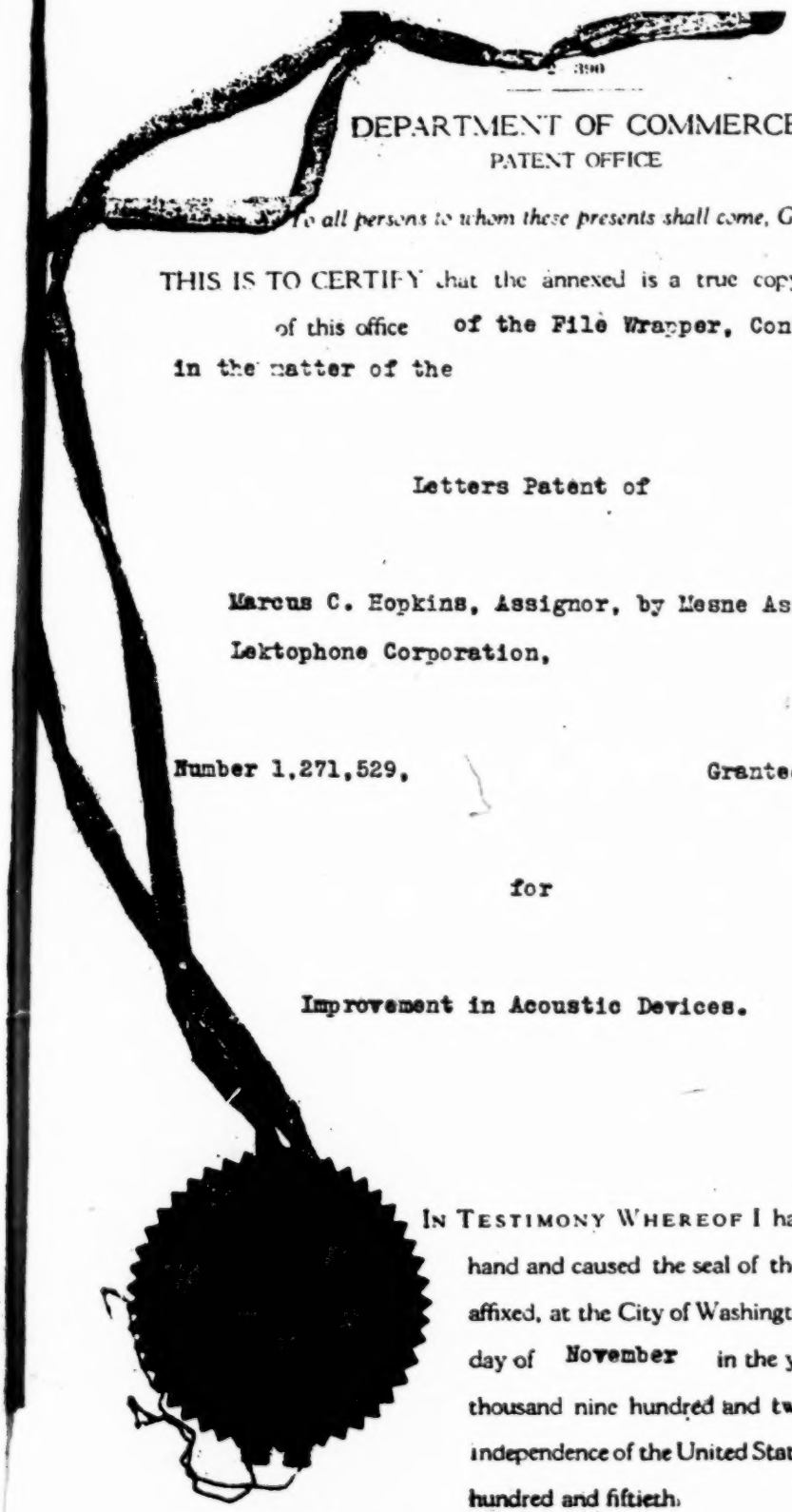
And now, to-wit, this fourth day of March, A. D. 1930, upon reading and considering the foregoing stipulation, it is, upon motion of William H. Foulk, Esq., solicitor for defendant,

ORDERED by the Court that the foregoing condensed statement of the record of proceedings at the trial of said cause, to be incorporated in the transcript of record on appeal, be and hereby is approved.

(Sgd.) HUGH M. MORRIS, *J.*

EXHIBITS

PLAINTIFF'S EXHIBIT No. 1.



DEPARTMENT OF COMMERCE
PATENT OFFICE

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the File Wrapper, Contents and Drawing, in the matter of the

Letters Patent of

Marcus C. Hopkins, Assignor, by Mesne Assignments, to Lektophone Corporation,

Number 1,271,529, Granted July 2, 1918,

for

Improvement in Acoustic Devices.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this fourteenth day of November in the year of our Lord, one thousand nine hundred and twenty-five and of the independence of the United States of America the one hundred and fiftieth.

ATTEST: D. Erbilsan
Chief of Division.

Thomas E. Robertson
Commissioner of Patents.

NUMBER (Series of 1- 5),

229014

1918

(EX'R'S BOOK) 108 76

DIV. 23

PATENT No. 1271529

Name Marcus C. Hopkins,

Assor by mesne assigt to Lektophone Corporation, of New York, N.Y., a Corp. of Delaware

of New York,

County of New York,

State of

Invention Acoustic Devices.

PARTS OF APPLICATION FILED.	ORIGINAL	RENEWED
Petition	April 12, 1918	, 191
Affidavit	" " , 1918	, 191
Specification	" " , 1918	, 191
Drawing	" " , 1918	, 191
Photo Copy	, 191	, 191
First Fee Cash $15	April 17, 1918	, 191
" " Cert.	, 191	, 191
Appl. filed complete	April 17, 1918	, 191
Examined and Passed for Issue	Apr 22, 1918	, 191
H. W. Grosbeck, Exr. Div. 23.		Exr. Div.
Notice of Allowance	June 29, 1918 By Commissioner.	, 191 By Commissioner
Final Fee Cash $20	June 3, 1918	, 191
" " Cert.	, 191	, 191
Patented	July 2, 1918	, 191

Division of App., No. 7158 ~ 1 Cancelled 229042 filed July 14 1913 Patented Aug. 27, 1918

Attorney Frank, Davis, Marvin & Edmonds, 35 Nassau St. New York, N.Y.

Associate Attorney

No. of Claims Allowed 7 Print Claims 1-4 in O. G. (C) 181-31

Title as Allowed Acoustic Devices

DEPARTMENT OF THE INTERIOR
UNITED STATES PATENT OFFICE
WASHINGTON

APR 17 1918 C.C.U.S. PAT OFFICE

DIV. 23

THE COMMISSIONER OF PATENTS.

Sir:

Please ~~furnish~~ apply filing fee of $15 here with application of Marcus C. Hopkins, Sound Regenerating Machine - ~~receive~~ filed Apr. 12/18

Pennie, Davis, Marvin & Edmonds

(Give full address.) 35 Nassau St. New York.

Cost $

Received $

Delivered , 191

2036
4-13

MAIL ROOM
APR
12
1918
U.S. PATENT OFFICE

529

PETITION

TO THE COMMISSIONER OF PATENTS:

Your petitioner, MARCUS C. HOPKINS, a citizen of the United States, residing in the borough of Manhattan, City, County and State of New York, whose Post Office address is No. 35 Nassau Street, New York City, N. Y., prays that Letters Patent may be granted to him for improvements in ACOUSTIC DEVICES, as set forth in the annexed specification.

AND he hereby appoints JOHN C. PENNIE, WILLIAM H. DAVIS, ARBA B. MARVIN and DEAN S. EDMONDS (constituting the firm of PENNIE, DAVIS, MARVIN & EDMONDS, 35 Nassau Street, New York City, Registration No. 10839), and each of them, his Attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to sign the drawings, to receive the patent, and to transact all business in the Patent Office connected therewith.

Marcus C. Hopkins

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, MARCUS C. HOPKINS, a citizen of the United States, residing in the Borough of Manhattan, City, County, and State of New York, have invented certain new and useful improvements in ACOUSTIC DEVICES; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains, to make and use the same.

This invention relates to instruments which reproduce sounds; and is particularly directed to the attainment of a direct propagation, in free air, from a record or equivalent element subjected to the action of the original sound waves or vibrations, of self-sustaining sound waves substantially corresponding in intensity and amplitude, as well as in pitch or timbre, to the said original sound waves, as distinguished from an initial generation of violent air disturbances in a confined space, and a subsequent transformation of such disturbances into self-sustaining sound waves by means of a megaphone, horn or other amplifier.

In the case of a talking machine, the device employed to propagate the regenerated sound waves in air comprises the reproducer or sound-box and the horn; but the reproducer alone is incapable of propagating sound waves of the character above stated because of the fact that the air disturbances which are produced by its diaphragm and which issue through its mouth-piece are almost immediately dissipated in heat or in waves which are not heard at any considerable distance if the horn be removed. Consequently, it is usual in all instruments of the class indicated to employ an amplifier of some sort to resist transformation into heat and to control the lateral form of the wave during a progressive spreading action which is accompanied by a lessening of the violence of the disturbance until a wave front of great area is attained having a movement appropriate to the sound conductivity of air. In this way, it has been found practicable to transform a satisfactory part of the energy, obtained from a moving record, into self-sustaining

sound waves in air; but in every instance such method has been accompanied by distortions of the true recorded sounds in the reproducer, and more particularly in the horn or amplifier, giving rise to those characteristic sounds known as phonograph and horn sounds. These distortions of the true sounds are in a measure impressed upon the record in its making, but are more noticeable in the reproduction, where a suppression of character and overtones, the loss of timbre in instruments and the voice, and the accentuation of notes of certain pitch, so change the recorded number that a faithful reproduction is not obtained.

It is the object of the present invention to regenerate the original sounds directly from the record or other element subjected to the action of such sounds, without interposition of a confined body of air and without the employment of a restrictive transformer, such as a horn. According to the invention, the sound regenerator comprises a tympanum of relatively great area freely exposed to unconfined air, in which the sounds are to be propagated; the vibrations produced by the record or its equivalent, that is, the element on which the original sounds or sound waves are recorded, or which is otherwise subjected to the vibrating action of said sounds or sound waves and may, therefore, be termed the "sound-vibrated" element---being faithfully transmitted to the tympanum in such manner that the latter excites directly in the free air surrounding it, sound waves of an intensity and amplitude substantially corresponding to the original sound waves. In other words, the original sounds are directly regenerated by the vibrating tympanum without the interposition of a restrictive or sound-modifying transformer.

The invention consists, briefly, in the provision of a tympanum of novel construction, which is capable of responding to the high frequency vibrations employed in the reproduction of sounds, and of imparting these vibrations to a large body of air; and it is to be considered as a division of the invention shown and described in my prior application, renewed March 22, 1918, No. 224,048.

The accompanying drawing illustrates the improved tympanum incorporated in a sound-reproducing machine of the kind disclosed in said application, the single figure being a vertical sectional view taken transversely through the machine. Reference may be had to this application for a disclosure of the complete machine; and in order to facilitate an understanding of the present invention as compared with such disclosure, the same reference characters will be employed as in the said earlier application to indicate corresponding parts.

The machine represented in said drawing is mounted within a cabinet having a deck A, upon which the motor (not shown) and the sound regenerator are mounted. Side walls B extend downwardly from the edges of the deck A, and are preferably apertured on all sides and provided with open-work grills C, which afford substantially uninterrupted air paths for the sound waves from the interior of the cabinet in all directions laterally to the surrounding atmosphere. In the machine shown, the cabinet is bottomless and provided with legs D at its four corners. The motor may be of any suitable type, and is connected to drive the shaft of the turn-table F through the intermediary of gearing, as is

usual, said shaft projecting upwardly through the deck A. The turn-table carries the record F', which in this instance is the element directly acted upon by the original sound vibrations which are to be subsequently regenerated or reproduced; that is to say, the record, in the present construction, is the "sound-vibrated" element.

The sound regenerator has a right-angled tubular support G, the vertical arm g of which is engaged at diametrically-opposite points by bearing screws h', which project inwardly from and are carried by a ring h of larger diameter than the said arm g, as described in said prior application. The screws h' form a horizontal axis perpendicular to the horizontal arm g'' of the right-angled support G, about which axis the arm g'' can swing in a vertical plane, the vertical arm g the while being inclined within the ring h. The latter forms part of an annular bearing device secured upon the deck A, the open central portion of which device alines with an opening of larger diameter in said deck, and the said vertical arm g of the support G extends downwardly through these openings and has its lower extremity fitted in the hub j of a conical spider J and fastened to the same by a set screw j'.

The spider J in the present construction has three arms, only two of which appear, however; and to the lower ends of these arms there is secured by screws an annulus consisting of two ponderous rings K, K' of metal, which are clamped together by screws k spaced at short intervals. Two of the three arms of the said spider are screwed tightly to the rings K,K', and the third is so arranged that the

rings K,K' can be secured at varying distances from the foot of this third arm, there being sufficient spring in the spider arms to permit of an adjustment at this point of one-quarter of an inch or so, if desired. This detail is illustrated in my earlier case, and for that reason is not represented in the present case.

The tympanum L, which forms the subject of the present case, is constructed of light, vibratile material and has an annular plane peripheral portion or supporting rim 1, the outer edge of which is tightly gripped and rigidly supported between the rings K,K', and a central conical portion 1' rising from the inner edge of the said rim 1. If satisfactory regeneration of sounds from a record or other sound-vibrated element is to be had, the whole diameter of the tympanum, that is, the diameter of the aperture in the rings K,K' should exceed nine inches in order that the conditions required to regenerate the sound waves in the manner above described shall be fulfilled. The base of the central conical portion 1' should exceed in area one-half of the effective area of the entire tympanum, that is, the area of the aperture in the rings K,K'; or in other words, the diameter of the base of said conical portion should be at least eight-tenths of the diameter of the said aperture. The altitude of the conical portion 1' should be at least one-quarter of the diameter of its base.

It is, of course, possible to make some variation from the approximate sizes given without materially altering the result; but if the tympanum is constructed as shown in the drawing, any great variation from these proportions will be found to affect the character of the reproduction. It is

of vital importance that the tympanum be made of crisp, strong material, having considerable rigidity within itself, and it is also of vital importance that the tympanum as a whole be extremely light and have as little inertia as possible without a weakening effect. The tympanum is shown of conical form with a smooth surface, and this has been found to be very satisfactory. The conical shape is given the tympanum so that shocks or vibrations impressed upon the apex of the cone in a direction towards its base will move the whole cone bodily, the strains being imparted edgewise of the material and no wave motions being set up in the thin material of the cone. The curvature of the walls of the cone precludes the setting up of waves in the material; and the intended object, a simultaneous movement of the whole conical portion of the tympanum, is thus attained. While I prefer to construct the tympanum in the form described and shown with a smooth surface, especially in view of the ease of construction, yet it is possible to form radial or concentric corrugations in the plane peripheral portion 1 and produce a light, stiff and very satisfactory article for the purpose. It is conceivable, too, that when the tympanum is provided with corrugations as just suggested, some variation from the proportions above given may be made; but such variations will not be great. The tympanum should preferably be constructed of a colloidal substance, and should be from 3 to 20 thousandths of an inch in thickness according to the crispness or stiff character of the material used. Compressed fibrous material, such as hot pressed paper or fibre, has been found to act satisfactorily.

It will benoted that in the construction illustrated,

the arms of the spider J incline downwardly to correspond with the conical shape of the tympanum L, the apex of the conical portion of the tympanum pointing upwardly toward the deck A of the cabinet, and, also, that the concave side of the said tympanum is open to the surrounding atmosphere through the open bottom of the cabinet, no obstructions being presanted to the sound waves issuing from the concave surface of the tympanum.

A cap M is secured to the apex of the conical portion l of the tympanum, and this cap should be of more rigid construction than the remainder of the tympanum and should preferably be three-eighths of an inch or more in diameter. I prefer to make the cap M of metal, extremely light but very rigid, and in the form of two cones m, m' screwed tightly together upon opposite sides of the tympanum so as to grip the material thereof with their edges. In order that a tight and positive application of the cones forming the cap M to the conical portion of the tympanum may be had, it is preferable to form the inner cone m' of lesser angle, and the outer cone m of greater angle than the said conical portion, in which case their edges will securely grip the tympanum material when they are fastened together.

The vibrations or sound waves originally imparted to the record or its equivalent may be transmitted therefrom to the tympanum to vibrate the same in the manner and by means of the mechanism shown and described in my aforesaid application above identified, or by means of some other approved transmission means or mechanism, as will be understood. In any event, such means or mechanism forms no part of the

present case, however, and for that reason requires no extended disclosure. It is believed sufficient to state, therefore, that in the arrangement illustrated the mechanism in question is located within thehorizontal arm g" of the support G, and is connected at its forward end with the stylus holder q, the other end of said mechanism having connected to it a vertical rod V, which extends downwardly through the interior of the vertical arm g of the support and is rigidly secured to the cap M of the tympanum. In consequence, the vibrations of the stylus q' mounted in said holder and produced in the usual way by the phonic lines on the record, will be transmitted from the stylus through the transmission mechanism to the rod V, which will be vibrated endwise, the endwise vibrations of said rod being directly impressed upon the tympanum L.

I CLAIM:

1. An acoustic device, comprising a tympanum rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion substantially eight-tenths of the diameter of said free area.

2. An acoustic device, comprising a tympanum rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion substantially eight-tenths of the diameter of said free area, said conical portion being rigid in the direction of the axis of the tympanum.

3. An acoustic device, comprising a tympanum rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion substantially eight-tenths of the diameter of said free area, the altitude of said conical portion being substantially one-quarter of the diameter of its base.

4. An acoustic device, comprising a tympanum support having a circular aperture, and a light tympanum freely exposed to unconfined air and having its outer edge rigidly mounted on said support in said aperture; said tympanum having a central conical portion, the base of which exceeds in area one-half the effective area of the said tympanum; the tympanum being of sufficient area to impart to the surrounding free air, when vibrated, sound waves substantially corresponding in intensity to the original sound waves.

5. An acoustic device, comprising a tympanum support having a circular aperture, and a light vibratile tympanum exceeding nine inches in diameter, having its

outer edge rigidly mounted on said support; said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the said circular aperture in said support.

6. An acoustic device, comprising a tympanum support having a circular aperture, and a light vibratile ~~diaphragm~~ tympanum mounted in said aperture and having its outer edge secured to said support; said tympanum being shaped to provide an annular rim, the ~~inner~~ outer diameter of which exceeds nine inches, and a conical portion springing from the inner edge of said annular rim, the altitude of said conical portion being substantially one-fourth of the diameter of its base.

7. An acoustic device, comprising a tympanum support having a circular aperture exceeding nine inches in diameter, and a light vibratile tympanum mounted in said aperture and having its outer edge rigidly secured to said support; said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the diameter of said circular aperture, and the altitude of said conical portion being substantially one-quarter of the diameter of its base.

Insert B

8. An acoustic device, comprising a tympanum of colloidal material rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion substantially eight-tenths of the

diameter of said free area, the altitude of said conical portion being substantially one-quarter of the diameter of its base.

9. An acoustic device, comprising a tympanum of compressed fibrous material rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion substantially eight-tenths of the diameter of said free area, the altitude of said conical portion being substantially one-quarter of the diameter of its base.

10. An acoustic device, comprising a tympanum of compressed fibrous material rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portinn substantially eight-tenths of the diameter of said free area.

11. An acoustic device, comprising a tympanum freely exposed to unconfined air and comprising a conical portion of compressed fibrous material, upon the apex of which portinn shocks or vibrations are adapted to be impressed in a direction such that said shocks or vibrations will move the entire conical portion bodily.

12. An acoustic device, comprising a tympanum freely exposed to unconfined air and comprising a conical portion upon the apex of which shocks or vibrations are adapted to be impressed in a direction such that said shocks or vibrations will move the entire conical portion bodily; said conical portion being of sufficient area to impart to the surrounding free air, when vibrated, sound

waves substantially corresponding in intensity to the original shocks or vibrations.

13. An accustic device, comprising a tympanum freely exposed to unconfined air and comprising a conical portion of compressed fibrous material, uponthe apex of which portion shocks or vibrations are adapted to be impressed in a direction such that said shocks or vibrations will move the entire conical portion bodily; the said conical portion being of sufficient area to impart to the surrounding free air, when vibrated, sound waves substantially corresponding in intensity to the original shocks or vibrations.

IN TESTIMONY WHEREOF I affix my signature.

Marcus C. Hopkins

OATH

COUNTY OF NEW YORK, : ss.-
State of New York- :

MARCUS C. HOPKINS, the above named petitioner, being duly sworn, deposes and says, that he is a citizen of the United States and a resident of the Borough of Manhattan, City, County and State of New York; that he verily believes himself to be the original, first and sole inventor of the improvements in ACOUSTIC DEVICES described and claimed in the annexed specification, which is a division of his former application for United States Letters Patent, Serial Number 778,826, filed July 14, 1913; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patents or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to his said application, or in public use or on sale in the United States for more than two years prior to his said application: that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to the said application; and that no application for patent on said improvement has been filed by him, or his representatives or assigns in any country foreign to the United States, except as follows:

Austria, filed July 14, 1914, Ser.No.A 6151;
Belgium, " " " " " " 220,014; Patented July 14,1914, No.269,216;
Canada, " " 28, 1915, Ser.No.196,573; Patented April 25, 1916, No.169,043:
Denmark, " " July 13, 1914, Ser.No.1,228; Patented January 25, 1916, No.20,972;

France, filed July 13, 1914, Ser.No. 72,606, Patented July 13, 1914, No. 475,109;
Germany, filed July 14, 1914, Ser.No. D 31161, Patented July 15, 1914, No. 286,137;
Great Britain, filed July 11, 1914, Ser.No. 16,602, patented July 14, 1913, No. 16,602;
Holland, filed June 11, 1915, Ser.No. 5,981;
Italy, filed July 15, 1914, Patent No. 144,682;
Norway, filed July 13, 1914, Ser.No. 6,718, Patent No. 26,721,
Sweden, filed July 11, 1914, Ser. No. 1,937;
Switzerland, filed July 14, 1914, Ser.No. 81,372, Patent No. 71,939.

Marcus C. Hopkins

SUBSCRIBED AND SWORN TO before me, this 6th day of April, 1918.

M. A. Bill
Notary Public
Cert filed N.Y. Co.
Notary # 255.

#2

DIV. 23

New York, N. Y., April 11, 1918

Honorable Commissioner of Patents

Washington, D. C.

S i r:

The application to which this communication is attached is filed as a division of a prior application of the same inventor, originally filed July 14, 1913, Serial No. 778,826, renewed March 22, 1918, Serial No. 224,048. The earlier application contains a disclosure of the complete machine or apparatus, whereas on the other hand, the present application is restricted to the diaphragm or tympanum per se. For that reason, the drawings of the earlier application contain many figures which have no bearing on the invention claimed in the present case, and during a discussion with the Examiner in charge of the earlier case, the suggestion was made by him that the divisional case be restricted to a single figure which would show as little as possible of the structure irrelevant to the invention. This course has accordingly been followed, the single figure of the present case corresponding to the Fig. 4 of the earlier application.

Very respectfully,

Pennie, Davis, Marvin & Edmonds

Attorneys for Applicant

12-3
4213

#3
a

IN THE UNITED STATES PATENT OFFICE.

Application of MARCUS C. HOPKINS

Filed April 17, 1918

Serial No. 229,014

SOUND REGENERATING MACHINES.

New York, N. Y., April 19, 1918

Honorable Commissioner of Patents

Washington, D. C.

S i r:

Prior to action on the merits of the case, entry of the following amendments is hereby directed:

In lines 3 and 4 of each of Claims, 1, 2 and 3, change, "substantially" to "the diameter of which is not less than".

Claim 6, line 5, change "inner" to "outer".

Cancel Claims 8 to 13, inclusive.

The amendments to Claims 1 to 3, and 6, have been made to render the present case consistent with the disclosure in the parent case, Serial No. 778,826, filed July 14, 1913.

Claims 8 to 13 have been cancelled in order to reduce the number of claims and for the further reason that the subjects matter thereof are adequately covered in the claims retained.

Very respectfully,

Pennie, Davis, Marvin & Edmonds

Attorneys for Hopkins.

2-073

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON

PETITION: June 5, 1918

Application of M. C. Hopkins

Serial No. 229,014

Invention:

This petition is referred to the Examiner in charge of Division 23 for recommendation.

In case he recommends adversely he will state his reasons therefor and furnish a copy thereof to petitioner.

J. T. Newton

Commissioner of Patents.

DIV. 23

Fee June 3/18 #4

B 1576

Div. 23.

IN THE UNITED STATES PATENT OFFICE

Application of
Marcus C. Hopkins,
Filed April 17, 1918,
Serial No. 229,014.
SOUND REGENERATING MACHINES.
Allowed April 29, 1918.

New York City, June 3, 1918.

Hon. Commissioner of Patents,
Washington, D.C.

S I R:

Entry of the following additional claim is requested under the provisions of Rule 78.

"8. An acoustic device, comprising a tympanum embodying a bodily movable, central conical portion, and an annular rim which encircles said conical portion and which is rigidly supported, said conical portion being freely exposed on all sides to unconfined air and being of sufficient area to produce self-sustaining sound waves in the surrounding air when vibrated, substantially as described."

P.D.M. 6 B'

Diga.

REMARKS:

The above claim as been submitted informally to both the Principal and Assistant Examiners in charge of the case, and has been accpeted as allowable, no further search being necessary.

Very respectfully,

Pennie, Davis, Marvin & Edmonds
Attorneys for Hopkins.

APPROVED:
JUN 6 1918
First Assistant Commissioner.

The proposed ~~correction in form~~ claim requiring no further search, ~~format~~, it is recommended that this amendment be entered under Rule 78, without withdrawing the case from issue. The final fee has not been paid.

H. D. Emerson, Examiner Div. 23.

Div. 23 Room 217
Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

254

Paper No. 5
All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

B-T

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON June 8, 1918.

EXAMINER'S AMENDMENT.

Pennie, Davis, Marvin & Edmonds,

35 Nassau St.

New York, N.Y.

Please find below a communication from the ***EXAMINER*** *in charge of the application of*

Marcus C. Hopkins, for Acoustic Devices, filed April 17, 1918, Serial No. 229,014.

James T. Newton

Commissioner of Patents.

In accordance with the provisions of Order No. 2308, dated March 12, 1917, which reads in part as follows:

* * * * * * *

> Obvious informalities in the application may be corrected by the examiner, but said correction must be in the form of an amendment, approved by the Principal Examiner in writing, placed in the file, and made a part of the record. The changes specified in the amendment will be entered by the clerk in the regular way.

* * * * * * * *

the changes, hereinafter specified, are made by the examiner in the application above identified.

Should these changes not be satisfactory to the applicant, appropriate amendment may be proposed under the provisions of Rule 78, provided the specification has not been printed.

The application has been amended as follows:

4—1556

Claim 6, line 3; change -diaphragm- to tympanum.

H. D. Crosbrek.

Examiner.

310

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

LETTER NO. 56

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON

June 7, 1918.

In the matter of the
Application of
Marcus C. Hopkins,
Acoustic Devices;
Filed April 17, 1918
Serial No. 229,014.

Amendment.

Sir:

You are hereby informed that the recommendation of the examiner that the amendment be admitted under the provisions of Rule 78, has been approved by the First Assistant Commissioner and the amendment entered.

By direction of the Commissioner:

Very respectfully,

M. H. Coulston,

Chief Clerk.

F.

Marcus C. Hopkins,
c/o Pennie, Davis, Marvin & Edmonds,
35 Nassau St.
New York City.

ADDRESS ONLY
THE COMMISSIONER OF PATENTS,
WASHINGTON, D. C.

AH 2—181 **Serial No. 229,014**

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON Apr,29,1918.

Marcus C. Hopkins, Assor.,

Sir: Your APPLICATION for a patent for an IMPROVEMENT in Acoustic Devices, filed April 17,1918., has been examined and ALLOWED.

The final fee, TWENTY DOLLARS, must be paid not later than SIX MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent on this application will be withheld, unless renewed with an additional fee of $15, under the provisions of Section 4897, Revised Statutes.

The office delivers patents upon the day of their date, and on which their term begins to run. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will require about four weeks, and such work will not be undertaken until after payment of the necessary fee.

When you send the final fee you will also send, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If you desire to have the patent issue to ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of FIVE CENTS EACH. The money should accompany the order. Postage stamps will not be received.

Final fees will NOT be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Respectfully,

J. T. Newton
Thomas Ewing
Commissioner of Patents.

Pennie, Davis, Marvin & Edmonds,

35 Nassau Street,

New York, N. Y.

229,014
23

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED.

312

20 REC'D JUN 3 1918 U.S. PAT. OFFICE

4213

-327.

MEMORANDUM

OF

FEE PAID AT UNITED STATES PATENT OFFICE.

(Be careful to give correct Serial No.)

Serial No. 229,014 June 1, 191 8.

INVENTOR:

MARCUS C. HOPKINS

PATENT TO BE ISSUED TO

LEKTOPHONE CORPORATION

NAME OF INVENTION, AS ALLOWED:

ACOUSTIC DEVICES

DATE OF PAYMENT:

June 3, 1918.

FEE:

TWENTY DOLLARS

DATE OF FILING:

April 17, 1918.

DATE OF CIRCULAR OF ALLOWANCE:

April 29, 1918.

The Commissioner of Patents will please apply the accompanying fee as indicated above.

Pennie, Davis, Marvin & Edmonds

Attorney

SEND PATENT TO

PENNIE, DAVIS, MARVIN & EDMONDS,

35 Nassau Street,

New York City.

6—1846

MAIL ROOM NOV 4 1924 U.S. PATENT OFFICE

United States District Court

#7.

District of New York.

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 ~~(41 Stat. L.~~ 42 Stat. L. 392), you are advised that there was filed on the 31st day of October, 1924, in this court an action, suit, or proceeding No. E 20-234, entitled:

Name Lektaphone Corporation, Plaintiff,
Address Jersey City N. J.

versus

Name Western Electric Company Inc., Defendant,
Address New York. N.Y.

brought upon the following patents:

	PATENT NO	DATE OF PATENT	PATENTEE
1.	1,271,529	Apr 17. 1918	Lektaphone Corp
2.			
3.			
4.			
5.			

In the above-entitled case, on the ..... day of ....., 192 , the following patents have been included by ..... (insert amendment, answer, cross bill, or other pleading):

	PATENT NO.	DATE OF PATENT	PATENTEE
1.			
2.			
3.			
4.			
5.			

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

In witness whereof I have affixed my hand this 3rd day of November, 192 4, at New York. N.Y.

Alexander Gilchrist Jr.
Clerk of said Court.

MAIL ROOM MAY 28 1925

United States District Court

Eastern District of New-York

#19

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 (42 Stat. L. .....), you are advised that there was filed on the 3rd day of March, 1925, in this court an action, suit, or proceeding No. 2075, entitled:

Name Telephone Corp, Plaintiff,
Address Jersey City, N.J.

versus

Name Sylo Lighting Fixture Co, Defendant,
Address 166 Flatbush Ave., Brooklyn New York

brought upon the following patents:

PATENT NO.	DATE OF PATENT	PATENTEE
1. 1271527	July 2, 1918	Plaintiff co. Assignee
2. 1271529	" " "	" " "
3.		
4.		
5.		

In the above-entitled case, on the ..... day of ....., 192 , the following patents have been included by ..... (insert amendment, answer, cross bill, or other pleading):

PATENT NO.	DATE OF PATENT	PATENTEE
1.		
2.		
3.		
4.		
5.		

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

In witness whereof I have affixed my hand this 25th day of May, 1925, at Brooklyn New York.

Percy J. Bilken
Clerk of said Court.

Form 788

#20

MAIL ROOM NOV 3 1925 U.S. PATENT OFFICE

United States District Court

District of NEW JERSEY

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 ~~42 Stat. L.~~ 42, you are advised that there was filed on the 4th day of September, 1925, in this court an action, suit, or proceeding No. E-1431, entitled:

Name Lektophone Corporation, Plaintiff,

Address Jersey City, N. J.

versus

Name De Forest Radio Company, Defendant,

Address 139 Franklin St., Jersey City, N. J.

brought upon the following patents:

	PATENT NO.	DATE OF PATENT	PATENTEE
1	1,271,527	July 14, 1913	Marcus C. Hopkins
2	1,271,529	July 14, 1913	Marcus C. Hopkins
3			
4			
5			

In the above-entitled case, on the ..... day of ....., 192 , the following patents have been included by ..... (insert amendment, answer, cross bill, or other pleading):

	PATENT NO.	DATE OF PATENT	PATENTEE
1			
2			
3			
4			
5			

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

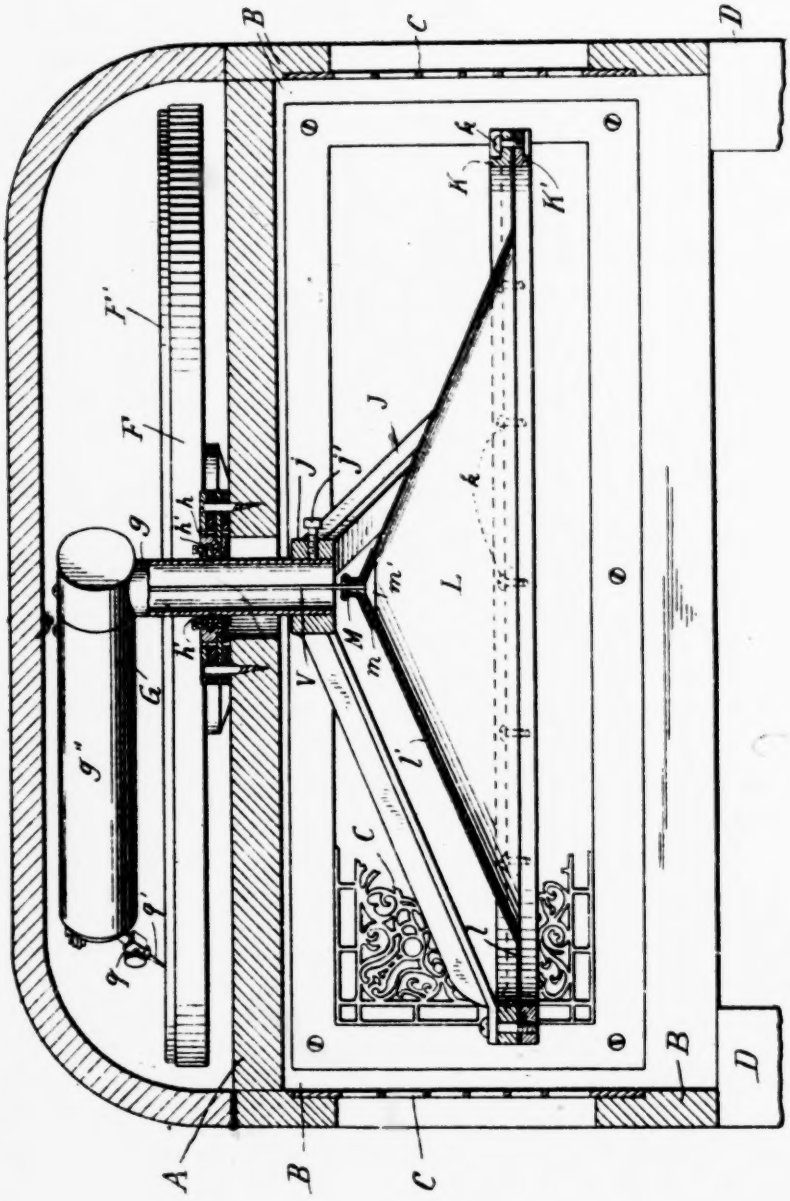
In witness whereof I have affixed my hand this 28th day of October, 1925, at Trenton, N. J.

George T. Cranmer
Clerk of said Court.

R. S. Chevrier, Deputy.

1,271,529.

Patented July 2, 1918.



Inventor
Marcus C. Hopkins

By Attorneys
Pennie, Davis, Marvin & Edmonds

UNITED STATES PATENT OFFICE.

MARCUS C. HOPKINS, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO LEKTOPHONE CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

ACOUSTIC DEVICE.

1,271,529. Specification of Letters Patent. Patented July 2, 1918.

Original application filed July 14, 1913. Serial No. 778,826. Renewed March 22, 1918. Serial No. 224,048. Divided and this application filed April 17, 1918. Serial No. 229,014.

To all whom it may concern:

Be it known that I, MARCUS C. HOPKINS, a citizen of the United States, residing in the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Acoustic Devices; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to instruments which reproduce sounds; and is particularly directed to the attainment of a direct propagation, in free air, from a record or equivalent element subjected to the action of the original sound waves or vibrations, of self-sustaining sound waves substantially corresponding in intensity and amplitude, as well as in pitch or timbre, to the said original sound waves, as distinguished from an initial generation of violent air disturbances in a confined space, and a subsequent transformation of such disturbances into self-sustaining sound waves by means of a megaphone, horn or other amplifier.

In the case of a talking machine, the device employed to propagate the regenerated sound waves in air comprises the reproducer or sound-box and the horn; but the reproducer alone is incapable of propagating sound waves of the character above stated because of the fact that the air disturbances which are produced by its diaphragm and which issue through its mouth-piece are almost immediately dissipated in heat or in waves which are not heard at any considerable distance if the horn be removed. Consequently, it is usual in all instruments of the class indicated to employ an amplifier of some sort to resist transformation into heat and to control the lateral form of the wave during a progressive spreading action which is accompanied by a lessening of the violence of the disturbance until a wave front of great area is attained having a movement appropriate to the sound conductivity of air. In this way, it has been found practicable to transform a satisfactory part of the energy, obtained from a moving record, into self-sustaining sound waves in air; but in every instance such method has been accompanied by distortions of the true recorded sounds in the reproducer, and more particularly in the horn or amplifier, giving rise to those characteristic sounds known as phonograph and horn sounds. These distortions of the true sounds are in a measure impressed upon the record in its making, but are more noticeable in the reproduction, where a suppression of character and overtones, the loss of timbre in instruments and the voice, and the accentuation of notes of certain pitch, so change the recorded number that a faithful reproduction is not obtained.

It is the object of the present invention to regenerate the original sounds directly from the record or other element subjected to the action of such sounds, without interposition of a confined body of air and without the employment of a restrictive transformer, such as a horn. According to the invention, the sound regenerator comprises a tympanum of relatively great area freely exposed to unconfined air, in which the sounds are to be propagated; the vibrations produced by the record or its equivalent,—that is, the element on which the original sounds or sound waves are recorded, or which is otherwise subjected to the vibrating action of said sounds or sound waves and may, therefore, be termed the "sound-vibrated" element—being faithfully transmitted to the tympanum in such manner that the latter excites directly in the free air surrounding it, sound waves of an intensity and amplitude substantially corresponding to the original sound waves. In other words, the original sounds are directly regenerated by the vibrating tympanum without the interposition of a restrictive or sound-modifying transformer.

The invention consists, briefly, in the provision of a tympanum of novel construction, which is capable of responding to the high frequency vibrations employed in the reproduction of sounds, and of imparting these vibrations to a large body of air; and it is to be considered as a division of the invention shown and described in my prior application, renewed March 22, 1918, No. 224,048.

The accompanying drawing illustrates the improved tympanum incorporated in a sound-reproducing machine of the kind disclosed in said application, the single figure being a vertical sectional view taken transversely through the machine. Reference

may be had to this application for a disclosure of the complete machine; and in order to facilitate an understanding of the present invention as compared with such disclosure, the same reference characters will be employed as in the said earlier application to indicate corresponding parts.

The machine represented in said drawing is mounted within a cabinet having a deck A, upon which the motor (not shown) and the sound regenerator are mounted. Side walls B extend downwardly from the edges of the deck A, and are preferably apertured on all sides and provided with open-work grills C, which afford substantially uninterrupted air paths for the sound waves from the interior of the cabinet in all directions laterally to the surrounding atmosphere. In the machine shown, the cabinet is bottomless and provided with legs D at its four corners. The motor may be of any suitable type, and is connected to drive the shaft of the turn-table F through the intermediary of gearing, as is usual, said shaft projecting upwardly through the deck A. The turn-table carries the record F', which in this instance is the element directly acted upon by the original sound vibrations which are to be subsequently regenerated or reproduced; that is to say, the record, in the present construction, is the "sound-vibrated" element.

The sound regenerator has a right-angled tubular support G, the vertical arm g of which is engaged at diametrically-opposite points by bearing screws h', which project inwardly from and are carried by a ring h of larger diameter than the said arm g, as described in said prior application. The screws h' form a horizontal axis perpendicular to the horizontal arm g'' of the right-angled support G, about which axis the arm g'' can swing in a vertical plane, the vertical arm g the while being inclined within the ring h. The latter forms part of an annular bearing device secured upon the deck A, the open central portion of which device alines with an opening of larger diameter in said deck, and the said vertical arm g of the support G extends downwardly through these openings and has its lower extremity fitted in the hub j of a conical spider J and fastened to the same by a set screw j'.

The spider J in the present construction has three arms, only two of which appear, however; and to the lower ends of these arms there is secured by screws an annulus consisting of two ponderous rings K, K' of metal, which are clamped together by screws k spaced at short intervals. Two of the three arms of the said spider are screwed tightly to the rings K, K', and the third is so arranged that the rings K, K' can be secured at varying distances from the foot of this third arm, there being sufficient spring in the spider arms to permit of an adjustment at this point of one-quarter of an inch or so, if desired. This detail is illustrated in my earlier case, and for that reason is not represented in the present case.

The tympanum L, which forms the subject of the present case, is constructed of light, vibratile material and has an annular plane peripheral portion or supporting rim l, the outer edge of which is tightly gripped and rigidly supported between the rings K, K', and a central conical portion l' rising from the inner edge of the said rim l. If satisfactory regeneration of sounds from a record or other sound-vibrated element is to be had, the whole diameter of the tympanum, that is, the diameter of the aperture in the rings K, K' should exceed nine inches in order that the conditions required to regenerate the sound waves in the manner above described shall be fulfilled. The base of the central conical portion l' should exceed in area one-half of the effective area of the entire tympanum, that is, the area of the aperture in the rings K, K'; or in other words, the diameter of the base of said conical portion should be at least eight-tenths of the diameter of the said aperture. The altitude of the conical portion l' should be at least one-quarter of the diameter of its base.

It is, of course, possible to make some variation from the approximate sizes given without materially altering the result; but if the tympanum is constructed as shown in the drawing, any great variation from these proportions will be found to affect the character of the reproduction. It is of vital importance that the tympanum be made of crisp, strong material, having considerable rigidity within itself, and it is also of vital importance that the tympanum as a whole be extremely light and have as little inertia as possible without a weakening effect. The tympanum is shown of conical form with a smooth surface, and this has been found to be very satisfactory. The conical shape is given the tympanum so that shocks or vibrations impressed upon the apex of the cone in a direction toward its base will move the whole cone bodily, the strains being imparted edgewise of the material and no wave motions being set up in the thin material of the cone. The curvature of the walls of the cone precludes the setting up of waves in the material; and the intended object, a simultaneous movement of the whole conical portion of the tympanum, is thus attained. While I prefer to construct the tympanum in the form described and shown with a smooth surface, especially in view of the ease of construction, yet it is possible to form radial or concentric corrugations in the plane peripheral portion l and produce a light, stiff and very satisfactory article

for the purpose. It is conceivable, too, that when the tympanum is provided with corrugations as just suggested, some variation from the proportions above given may be made; but such variations will not be great. The tympanum should preferably be constructed of a colloidal substance, and should be from 3 to 20 thousandths of an inch in thickness according to the crispness or stiff character of the material used. Compressed fibrous material, such as hot pressed paper or fiber, has been found to act satisfactorily.

It will be noted that in the construction illustrated, the arms of the spider J incline downwardly to correspond with the conical shape of the tympanum L, the apex of the conical portion of the tympanum pointing upwardly toward the deck A of the cabinet, and, also, that the concave side of the said tympanum is open to the surrounding atmosphere through the open bottom of the cabinet, no obstructions being presented to the sound waves issuing from the concave surface of the tympanum.

A cap M is secured to the apex of the conical portion *l* of the tympanum, and this cap should be of more rigid construction than the remainder of the tympanum and should preferably be three-eighths of an inch or more in diameter. I prefer to make the cap M of metal, extremely light but very rigid, and in the form of two cones *m*, *m'* screwed tightly together upon opposite sides of the tympanum so as to grip the material thereof with their edges. In order that a tight and positive application of the cones forming the cap M to the conical portion of the tympanum may be had, it is preferable to form the inner cone *m'* of lesser angle, and the outer cone *m* of greater angle than the said conical portion, in which case their edges will securely grip the tympanum material when they are fastened together.

The vibrations or sound waves originally imparted to the record or its equivalent may be transmitted therefrom to the tympanum to vibrate the same in the manner and by means of the mechanism shown and described in my aforesaid application above identified, or by means of some other approved transmission means or mechanism, as will be understood. In any event, such means or mechanism forms no part of the present case, however, and for that reason requires no extended disclosure. It is believed sufficient to state, therefore, that in the arrangement illustrated the mechanism in question is located within the horizontal arm *g''* of the support G, and is connected at its forward end with the stylus holder *q*, the other end of said mechanism having connected to it a vertical rod V, which extends downwardly through the interior of the vertical arm *g* of the support and is rigidly secured to the cap M of the tympanum. In consequence, the vibrations of the stylus *q'* mounted in said holder and produced in the usual way by the phonic lines on the record, will be transmitted from the stylus through the transmission mechanism to the rod V, which will be vibrated endwise, the endwise vibrations of said rod being directly impressed upon the tympanum L.

I claim:

1. An acoustic device, comprising a tympanum rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion, the diameter of which is not less than eight-tenths of the diameter of said free area.

2. An acoustic device, comprising a tympanum rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion, the diameter of which is not less than eight-tenths of the diameter of said free area, said conical portion being rigid in the direction of the axis of the tympanum.

3. An acoustic device, comprising a tympanum rigidly supported at its periphery and having a free area exceeding nine inches in diameter and a conical portion, the diameter of which is not less than eight-tenths of the diameter of said free area, the altitude of said conical portion being substantially one-quarter of the diameter of its base.

4. An acoustic device, comprising a tympanum support having a circular aperture, and a light tympanum freely exposed to unconfined air and having its outer edge rigidly mounted on said support in said aperture; said tympanum having a central conical portion, the base of which exceeds in area one-half the effective area of the said tympanum; the tympanum being of sufficient area to impart to the surrounding free air, when vibrated, sound waves substantially corresponding in intensity to the original sound waves.

5. An acoustic device, comprising a tympanum support having a circular aperture, and a light vibratile tympanum exceeding nine inches in diameter, having its outer edge rigidly mounted on said support; said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the said circular aperture in said support.

6. An acoustic device, comprising a tympanum support having a circular aperture, and a light vibratile tympanum mounted in said aperture and having its outer edge secured to said support; said tympanum being shaped to provide an annular rim, the outer

diameter of which exceeds nine inches, and a conical portion springing from the inner edge of said annular rim, the altitude of said conical portion being substantially one-fourth of the diameter of its base.

7. Au acoustic device, comprising a tympanum support having a circular aperture exceeding nine inches in diameter, and a light vibratile tympanum mounted in said aperture and having its outer edge rigidly secured to said support; said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the diameter of said circular aperture, and the altitude of said conical portion being substantially one-quarter of the diameter of its base.

8. An acoustic device, comprising a tympanum embodying a bodily movable, central conical portion, and an annular rim which encircles said conical portion and which is rigidly supported, said conical portion being freely exposed on all sides to unconfined air and being of sufficient area to produce self-sustaining sound waves in the surrounding air when vibrated, substantially as described.

In testimony whereof I affix my signature.

MARCUS C. HOPKINS.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."

2-421

1918

CONTENTS.

1. Application 2 papers.
2. Letter ago. 12/18
3. Amndt. A. 4/8/18
4. Amndt. B. June 3/18
5. Fwd. Amdt. 4/8/18
6. Notice of entry of Amendment June 7/18
7. Notice of Suit Nov. 4-1924
8. (2) Notice of Suit Mar. 10-1926 May 26-1926
9. Notice of Suit Nov. 3-1925
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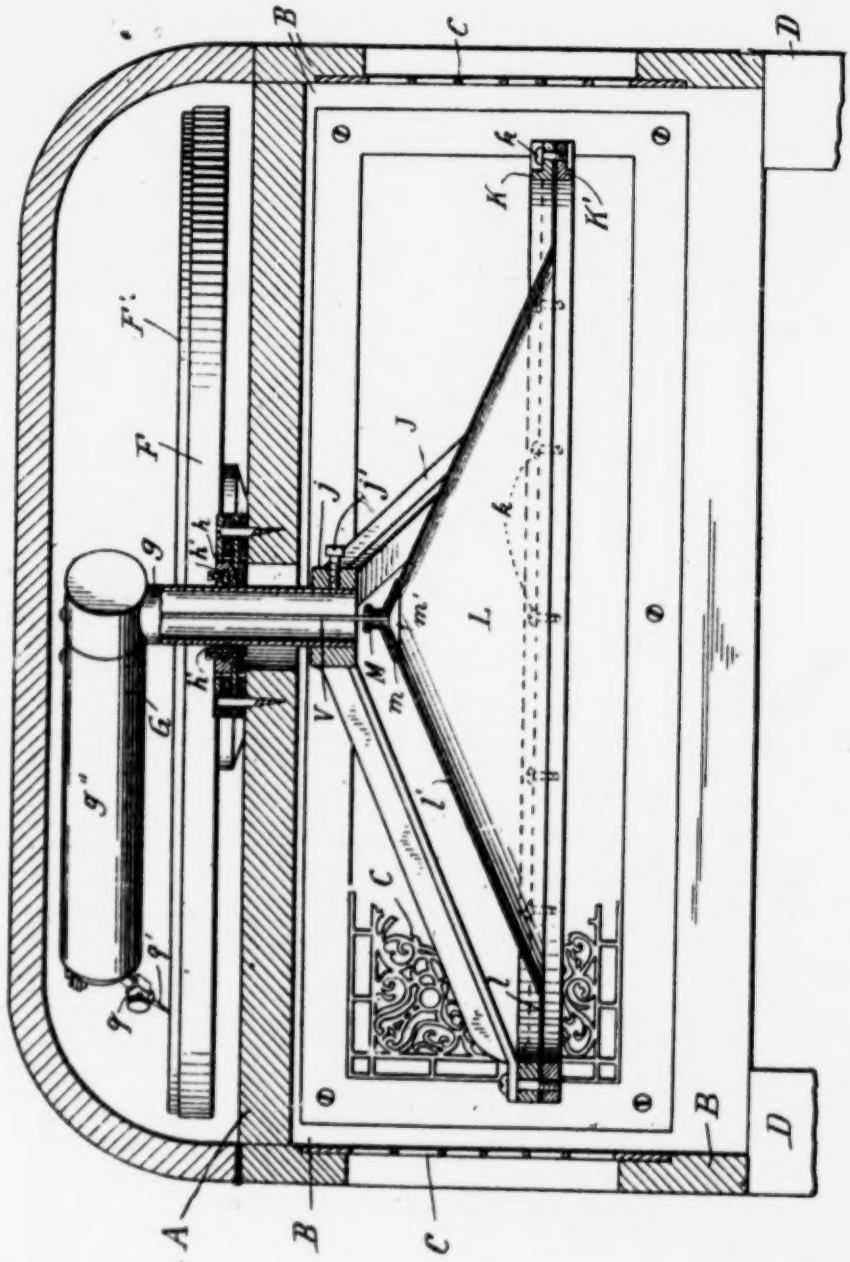
M. C. HOPKINS.

ACOUSTIC DEVICE.

APPLICATION FILED APR. 17, 1918.

1,271,529.

Patented July 2, 1918.



Inventor
Marcus C. Hopkins

By Attorneys
Pennie, Davis, Marvin & Edmonds

PLAINTIFF'S EXHIBIT No. 2.

DEPARTMENT OF COMMERCE
PATENT OFFICE

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the File Wrapper, Contents and Drawings, in the matter of the

Letters Patent of

Marcus C. Hopkins, Assignor, by Mesne Assignments, to Lektophone Corporation,

Number 1,271,527, Granted July 2, 1918;

for

Improvement in Sound-Regenerating Machines.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this fourteenth day of November in the year of our Lord, one thousand nine hundred and twenty-five and of the Independence of the United States of America the one hundred and fiftieth.

ATTEST:

Chief of Division.

Thomas E. Robertson
Commissioner of Patents.

Renewal. 2036

FORFEITED

DIV. 27

1913

(EXR'S BOOK) 28

NUMBER (Series of 1900) Series of 1915.

~~778,216~~ 224018 PATENT No. 1271527

Name Marcus C. Hopkins

Assignor to ~~John L. Bernard and William~~ H. Dan ~~Lash of Bayonne, N. J.~~ by mesne assignments to Lektophone Corporation of N. Y., New York, a Corp. of Delaware.

of Jersey City.

County of

State of New Jersey

Invention Sound Regenerating Machine

PARTS OF APPLICATION FILED.

	ORIGINAL	RENEWED
Petition	July 14, 1913	Mar. 22, 1918
Affidavit	" " , 1913	, 191
Specification	" " , 1913	Certificate of Correction , 191
Drawing 5 Sheet	" " , 1913	Sept 28 1920 , 191
Photo Copy	, 191	, 191
First Fee Cash $15.	July 14, 1913	$15. Mar. 22, 1918
" " Cert	, 191	, 191
Appl. filed complete	July 14, 1913	Mar. 22, 1918
Examined and passed for Issue	April 7 1916	April 23, 1918
W. A. Goubert Exr. Div.	2 3	W. D. Gouban Exr. Div. 23
Notice of Allowance	APR 11 1916 , 191	May 1 , 1918
Final Fee Cash	, 191	4523 June 3 , 1918
" " Cert	, 191	, 191
Patented		July 2 , 1918

Division of App., No. , Filed , 191

Attorney Pennie, Davis & Edmonds, Esqs. #35 Nassau Street New York N.Y.

Associate Attorney

No. of Claims Allowed 31 Title as Allowed Sound-Regenerating Machine (Cl. 274-1)

O.G. Dec 1-5

MEMORANDUM.

The first fee of $ 15 *, applied*

to the applicaiion of Marcus C. Hopkins

was included in composite letter No. .....

received July 14, 1913,

from Pennie, Davis & Goldsborough

which letter is on file in the Mail Room.

A. C. Cosden

Application Clerk.

6—1659

2836

TO THE COMMISSIONER OF PATENTS:

Your petitioner MARCUS C. HOPKINS, a citizen of the United States, residing at No. 2859 Boulevard, Jersey City, County of Hudson and State of New Jersey, and whose post-office address is No. 35 Nassau Street, New York City,

prays that Letters Patent may be granted to him for improvements in

SOUND REGENERATING MACHINE

as set forth in the annexed specification.

And he hereby appoints John C. Pennie and William H. Davis (constituting the firm of Pennie, Davis & Goldsborough, 35 Nassau Street, New York City), and each of them his Attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to sign the drawings, to receive the Patent, and to transact all business in the Patent Office connected therewith.

Marcus C. Hopkins.

SPECIFICATION.

ALL WHOM IT MAY CONCERN:

BE IT KNOWN, That I, MARCUS C. HOPKINS, a citizen of the United States, residing at No. 2859 Boulevard, Jersey City, County of Hudson, State of New Jersey,

have invented certain new and useful improvements in

SOUND-REGENERATING MACHINE;

and I do hereby declare the following to be a full, clear and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to instruments which reproduce sounds, such as the talking machine and the phonograph, and is particularly directed to the attainment of a direct propagation in free air from a record of self-sustaining sound waves ~~in air from a record~~, as distinguished from an initial generation of violent air disturbances in a confined space ~~which would not be propagated as sound~~, and a subsequent transformation of such disturbances into self-sustaining sound waves by means of the megaphone or trumpet, commonly employed with most existing machines.

The device employed to propagate such regenerated ~~self-sustaining~~ sound waves in air from a record I herein term a "regenerator", and this device in the phonograph and talking machine comprises the "reproducer" together with the trumpet. The "reproducer" alone is incapable of generating such ~~"self-sustaining"~~ sound waves in air, and the violent air disturbances which are produced by its diaphragm, which and issue through its mouth piece, are almost immediately dissipated in heat or ~~of small actions and high tension~~ in waves which are not heard ~~or in heat, as is at once apparent~~ at any considerable distance if the horn be removed.

In the case of the "reproducer", ~~it would appear that~~ all of the energy received from the record issues from its mouth as relatively violent ~~high tension~~ disturbances, which are impressed upon a very small amount of free air quite incapable of conducting such disturbances ~~of such tension~~ without transformation losses, and the trumpet is resorted to, therefore into heat to resist transformation and control the lateral form of the wave during a progressive spreading action, which is accompanied by a lessening of the violence of the disturbance ~~tension~~, until a wave front

of great area is attained ~~with a tension~~ having movement appropriate to the sound conductivity of air. In this way it has been found practicable to transform a satisfactory part of the energy obtained from a moving record, into self-sustaining sound waves in air, but in every instance this method has been accompanied by distortions of the true recorded sounds in the reproducer, and more particularly in the trumpet, giving rise to those characteristic sounds, known as phonograph and horn sounds. These distortions of the true sound are in a measure impressed upon the record in its making, but are more noticeable in the reproduction where a suppression of character and overtones, the loss of "timbre" in instruments and the voice, and the accentuation of notes of certain pitch, so change the recorded number that a faithful reproduction is ~~comparatively unknown~~ not obtained.

It is an object of the present invention to regenerate the recorded sounds directly from the record, without the interposition of a confined body of air or the employment of a restrictive transformer, such as a horn and without

The "sound regenerator", in the case of the present invention, comprises a tympanum of relatively great area freely exposed to the air, in which the sounds are to be propagated, ~~as such,~~ and a mechanical transmission which faithfully transmits the vibrations produced by the record, to the tympanum, in such manner that the tympanum excites sound ~~waves of a proper~~ such as tension to be self-sustaining in air, to a body of air of sufficient bulk to receive as

sound waves a satisfactory amount of the available energy receivable from the record without undue wear of the record.

The invention consists in providing a tympanum of novel construction, which is capable of responding to the high frequency vibrations employed in the reproduction of sounds and imparting these vibrations to a large body of air; in providing a suitable mounting for this tympanum to permit it to exercise its function, and in providing a vibration transmission for receiving the vibratory movement from the record and transmitting this movement to the tympanum, without change of character and appreciable loss of energy. The invention also comprehends certain combinations of parts and details of construction and location hereinafter particularly described and specifically pointed out in the appended claims.

I have illustrated in the accompanying drawings a sound reproducing machine embodying the several novel features of the invention as they may be employed in regenerating sounds from records made with either laterally or vertically sinuous grooves.

In the drawings,

Figure 1 is a plan view of the machine with the cover raised.

Figure 2 is a vertical section on line 2-2 of Fig. 1, with cover and transmission arm raised.

Figure 3 is a vertical section on line 3-3 of Fig. 1 with cover closed.

Figure 4 is a vertical section on line 2-2 of Fig. 1 with cover closed and transmission arm in playing position.

Figure 5 is a longitudinal section through the transmission arm on line 5-5 of Fig. 4.

Figure 6 is a vertical longitudinal section through the transmission arm on line 6-6 of Fig. 5.

Figure 7 is a vertical section on line 7-7 of Fig. 6.

Figure 8 is an end view of the transmission arm.

Figure 9 is a cross-section on line 9-9 of Fig. 5, and

Figure 10 is a view similar to Fig. 8 of a modified arrangement for vertically sinuous records.

Referring to the drawings, the illustrated machine is mounted within a cabinet having a deck A upon which the motor and sound regenerator are supported. Side walls B downwardly extending from the edges of the deck A are preferably apertured on all sides and provided with open work grills C which afford substantially uninterrupted air paths for the sound waves from the interior of the cabinet in all directions laterally to the surrounding atmosphere. In the machine shown the cabinet is bottomless and provided with legs D at its four corners.

The motor may be of any suitable type, that shown having a frame E, spring drums e, winding gear e', spiral drive gear e'', high pitch spiral table shaft e''' and governor e''''. The frame E of the motor is secured against the under side of the deck A depending therefrom

and the table shaft projects upwardly through the deck A and carries the circular record table F above the deck. The motor frame E is preferably insulated from the deck A by rubber washers not shown.

The sound regenerator has a right-angled tubular support G, the vertical arm g of which has diametrically opposite conical depressions g' which are engaged by pointed screws h' which project inwardly from and are threaded through a ring h of larger internal diameter than the external diameter of the vertical arm g of the right-angled support G. The pointed screws h' engage the depressions g' forming a horizontal axis perpendicular to the horizontal arm g'' of the right-angled support G about which axis the arm g'' can swing in a vertical plane, the vertical arm g the while being inclined within the ring h. The ring h comprises the ring h proper and an annular retaining plate h'' screwed upon the lower face of the ring h, an annular groove at the junction of the ring h and plate h'' receiving the inner edge of a holding plate H in such manner that the ring h and the right-angled support G may be turned about a vertical axis in the holding plate H.

The holding plate H is clamped between two rubber or felt rings i, i', the lower ring i' resting upon the deck A. A ring I is placed upon the top of the upper ring i and screws i'' have their heads seated in the ring I and are screwed down into the deck A. The ring H and the rubber or felt rings i and i' have large holes through which the screws i'' pass, so that these screws do not

come into contact with the ring H and the right-angled support G is therefore entirely insulated from the deck A by the rubber or felt rings. The vertical arm g of the right-angled support G extends downwardly through an aperture in the deck A at a point near the periphery of the record table F. A conical spider J shown as having three arms has its hub j fitted to the lower extremity of the vertical arm g of the right-angled support G, and is secured thereon by a set screw j'. To the ends of the arms of the spider J is secured by screws an annulus consisting of two ponderous rings K,K' of metal, these two rings being clamped together by screws k spaced at short intervals. ~~The spider J is shown having three arms, two of which~~ are screwed tightly to the rings K,K' and the third is as tightly secured to said rings but by adjustable screws k', k'' arranged in such manner that the rings K, K' can be secured at varying distances from the foot of this third leg, there being sufficient spring in the spider legs to permit of an adjustment at this point of one-quarter of an inch or so, if desired. It will be seen that owing to the proximity of the mounting of the vertical arm g of the right-angled support G to the edge of the record table F, the spider J and the rings K,K' will underlie the record table and permit of a very compact arrangement of the working parts within the cabinet.

A tympanum L of light vibratile material has an annular plane peripheral portion 1, the outer edge of which peripheral portion 1 is tightly gripped between the

ponderous rings K,K', and a central conical portion 1' riding from the inner edge of the annular plane peripheral portion. If satisfactory regeneration of sounds from a record is to be had, the whole diameter of the tympanum, that is, the diameter of the aperture in the rings K,K', should exceed nine inches in order that the conditions shall be fulfilled ~~which are called for by the correlation~~ existing between the range of wave frequencies of the sounds which must be regenerated by a machine of this character and the wave tension called for by the sound conductibility of free air. The base of the central conical portion 1' of the tympanum should exceed in area one-half the effective area of the entire tympanum, that is, the area of the aperture in the rings K,K'; or in other words, the diameter of the base of said conical portion should be ~~substantially~~ at least eight-tenths of the diameter of the circular aperture in the supporting rings K,K'. The altitude of the conical portion 1' of the tympanum should be ~~substantially~~ at least one-quarter of the diameter of its base. It is, of course, possible to make some variation from the approximate sizes given without materially altering the result, but if the tympanum is made as shown in the drawings, any great variation from these proportions will be found to affect the character of the reproduction. It is of vital importance that the tympanum be made of crisp, strong material, having considerable rigidity within itself, and it is also of vital importance that the tympanum as a whole be extremely light and have as little inertia a

possible without a weakening effect. The tympanum is shown of conical form with a smooth surface, and this has been found to be very satisfactory. The conical shape is given the tympanum so that shocks or vibrations impressed upon the apex of the cone in a direction toward its base will move the whole cone bodily, the strains being imparted edgewise of the material and no wave motions being set up in the thin material of the cone. The curvature of the walls of the cone preclude the setting up of waves in the material and the intended object, a simultaneous movement of the whole conical portion of the tympanum, is attained. While I prefer to construct the tympanum in the form described and shown with a smooth surface, especially in view of the ease of construction, yet it is possible to form radial corrugations in the conical portion 1' and radial or concentric corrugations in the plane peripheral portion 1 and produce a light, stiff and very satisfactory article for the purpose. It is possible that when the tympanum is provided with corrugations as just suggested, some variation from the proportions above given may be found possible, and perhaps advisable, but such variations from the proportions given will not be great. The tympanum should preferably be constructed of a colloidal substance and should be from 3 to 20 thousandths of an inch in thickness according to the crispness or stiff character of the material used. Compressed fibrous material, such as hot pressed paper or fibre, has been found to act satisfactorily, ~~but I prefer to employ hard rubber or vulcanite, as it~~

is more easily handled, is less affected by weather conditions and lends itself to the production of a more finished commercial product. The hard rubber is pressed to shape while hot from the sheet and allowed to cool in the die. If a polished sheet has been used, the finished tympanum will have a beautifully polished appearance. It will be noted that the arms of the spider J incline downwardly to correspond with the conical shape of the tympanum L and that the apex of the conical portion of the tympanum is pointed upwardly toward the deck A of the cabinet, and that the concave side of the tympanum is open to the surrounding atmosphere through the open bottom of the cabinet, no obstructions being presented to the sound waves issuing from the concave surface of the tympanum. It is probable that various forms of cabinets will be devised for machines of this character, but in practically every case it may be assumed that one side of the tympanum will be directed toward some reflecting surface or portion of the cabinet or machine which will in a measure obstruct the sound waves issuing from the tympanum and in every such case the tympanum should have its convex side directed towards the obstruction and its concave side as open as possible toward the free air. This is suggested because the shape of the tympanum admits of a more intense pressive action in propagating a sound wave when a shock is applied to its apex in a direction toward its base than in the opposite direction.

A cap M is secured to the apex of the conical por-

a cap M is secured to the apex of the conical por-
l'
tion l' of the tympanum L, and this cap should be of more rigid construction than the remainder of the tympanum and should preferably be three-eighths of an inch or more in diameter. I prefer to make the cap M of metal, extremely light but very rigid, and in the form of two cones m, m' screwed tightly together upon opposite sides of the tympanum and gripping with their edges the material of the conical portion of the tympanum. In order that a tight and positive application of the cones forming the cap M to the conical portion of the tympanum may be had, it is preferable to form the cone m' of lesser angle than the conical portion of the tympanum, and the cone m of greater angle than the conical portion of the tympanum, in which case their edges will securely grip the tympanum material when they are secured together. The cap M is applied to the tympanum to receive the shocks which are to be applied to the tympanum as a whole, and convey them to sufficient of the material of the tympanum to insure the movement of the tympanum as a whole. This will be better understood, when it is considered that if the shock were applied to paper or hard rubber at a single small point, the inertia of the tympanum as a whole would be sufficient to resist the attack and the material would be distorted or dented at that point, the effect of the shock upon the tympanum as a whole being entirely lost. The cap M being of hard material such as metal will resist the bending action and distribute the shock to so much of the surface of the material of the tympanum as is capable of successfully resisting the shock, and it will

then be transmitted to the tympanum as a whole. The plane peripheral portion l of the tympanum maintains the place of the conical active portion of the tympanum and yields sufficiently to permit of the required motion of the conical portion, resisting, however, displacement of the conical portion in just that degree necessary to maintain the form and neutral postion of the active conical portion. Were the plane peripheral portion l of considerably greater width or markedly narrower than described, its function would be destroyed to a degree corresponding to the remoteness of the departure from the approximate proportion given and the effective portion of the conical portion of the tympanum would be proportionately lessened.

In the tubular arm g'' of the transmission support G are located two ponderous members or weights N and N'. These members N and N' are shown as insulated from the wall of the arm g'' by a tube o of insulating material, such as soft rubber or felt. One at least of the ponderous members N and N' must be movable relatively to the other and therefore it cannot be rigidly secured to the support G, and the insulating material becomes necessary to avoid rattling. I preferably insulate both of the ponderous members or weights N, N' from the wall of the transmission support G. Pins P projecting from the ponderous member N, and sliding in holes in the other ponderous member N', act as guides and prevent disalinement and angular displacement of the movable ponderous member. Knife edge fulcra n and n' are secured in and project from the ends of the ponderous members N and N', and in

the form of the device shown in Figs. 1 to 9 the fulcra n are arranged horizontally and the fulcra n' are arranged vertically. A lever Q is mounted on the fulcra n' and is capable of movement upon a vertical axis. A style holder q projects from the lever Q downwardly at an incline so that the point of a style q' held in the style holder is considerably removed from the axis of the lever Q and movement given the style q' by the record will effect an oscillation of the lever Q about its vertical axis upon the fulcra n'. The lever Q has arms q'' and q''' projecting from opposite sides thereof, the arm q'' being near the top of the lever Q and the arm q''' being near the bottom of said lever. The reason for this arrangement of the arms upon the lever will presently appear.

A lever R is mounted upon the fulcra n and oscillates upon a horizontal axis. This lever has arms r and r' extending upwardly and downwardly from its opposite sides, the arm r projecting from a point near one end of the lever R, and the arm r' projecting from a point near the other end of the lever R. It will now be seen that a point upon the arm r of the lever R is opposite a similar point on the ~~xxx~~ arm q'' of the lever Q and these two points are connected by rod link S. It will also be seen that a point upon the arm r' of the lever R is opposite a point upon the arm q''' of the lever Q, and these two points are connected by a rod link S'. The rod links S and S' have eye-ends arranged in planes removed 90° from one another, and these eye-ends s are engaged by pivot screws s' upon the arms of the levers Q and R. A parall

elogram is formed by the levers Q and R and the rod links S and S', and in the form just described, which is adapted for a laterally sinuous groove in the record, oscillation of the lever Q about a vertical axis will produce like oscillations of the lever R about a horizontal axis. Springs T preferably mounted upon the pins P press the ponderous members N and N' apart forcing the knife edge-fulcra n and n' tightly against the levers R and Q, and put the parallelogram of levers and links under tension, precluding any rattle or looseness of the levers upon the fulcra or of the eye-ends of the links upon their pivot screws, and as the movable ponderous member of the combination is insulated from the transmission support G, no rattle or displacement of the parts can take place when the record groove oscillates the lever Q, but such oscillation will be faithfully transmitted to the lever R. The ponderous members N and N' have clearance holes s'' for the rod links S and S'.

An arm U projects from the central portion of the lever R, and to its end is rigidly secured a rod V which extends downwardly through the interior of the arm g of the transmission support G, its lower end being rigidly secured to the cap M of the tympanum. The rod V is nicked or thinned at v close to the arm U of the lever R to permit of a slight springing action which compensates for the very slight angular motion of the arm U when the lever R is oscillated. It will now be seen that the oscillation of the lever R about its horizontal axis imparted to it from the lever Q, will effect an endwise

vibration of the rod V which is directly impressed upon the tympanum L. A cap W closes the opening at the angle of the transmission support G and the removal of this cap gives access to the working parts of the rear end of the transmission.

When a vertically sinuous record is employed the lever Q is mounted to oscillate about a horizontal axis, as shown in Fig. 10, no change in the lever R being required.

1. The combination of a direct sound regenerating machine and a cabinet therefor having apertures on all sides affording substantially free paths for the sound waves from the regenerator containing cavity of the cabinet to the surrounding atmosphere; substantially as described.

2. The combination of a direct sound regenerating machine with a bottomless cabinet containing said machine; substantially as described.

3. The combination of a direct sound regenerating machine and a cabinet containing said machine, said cabinet having an aperture leading from the regenerator-containing compartment to the surrounding atmosphere.

4. The combination of a cabinet and a direct sound regenerating machine mounted therein and insulated therefrom; substantially as described.

5. The combination of a cabinet having two compartments and a partition therebetween, of a record table and tansmission arm located in ons of said compartments and a tympanum located in the other of said compartments and connected with said transmission arm; substantially as described.

6. In a direct sound regenerating machine, the combination of a partition, a transmission arm supported on said partition to swing upon one side thereof and extending therethrough and a tympanum supported upon said transmission arm to swing upon the other side of said partition; substantially as described.

7. In a direct sound regenerating machine, the combination of a horizontal partition, a transmission support

mounted upon said partition to swing thereover and extending downwardly therethrough and a tympanum carried upon said support beneath said partition; substantially as described.

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8. In a direct sound regenerating machine, the combination of a horizontal partition, a record holder mounted to rotate above said partition, a transmission support mounted upon said partition to swing above said record holder and extending downwardly through said partition and a tympanum carried by said support beneath said partition and under said record holder; substantially as described.

9. In a direct sound regenerating machine, the combination of a record holder, and a transmission support mounted to swing toward, from and across said record holder; substantially as described.

10. In a direct sound regenerating machine, the combination of a record holder, a transmission support mounted to swing over said record holder, and a tympanum carried by said support and extending under said record holder; substantially as described.

11. In a direct sound regenerating machine, the combination with a record holder, of a transmission support mounted to swing about vertical and horizontal axes, said support having an arm extended to move above and across said record holder having a free end and a second arm at the free end of which a tympanum carried by said second arm with its axis at an angle to said first arm; substantially as described.

12. In a direct sound regenerating machine, the combination of a bottomless cabinet supported upon legs and a downwardly directed tympanum mounted within said cabinet; substantially as described.

12. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram having opposite sides mounted on said fulcra and means exerting pressure upon said ponderous members to place said parallelogram under tension; substantially as described.

13. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram of non-extensible links and non-flexible levers, the levers of said parallelogram being mounted on said fulcra, and means exerting pressure upon said ponderous members to place said parallelogram under tension; substantially as described.

14. A sound regenerator for directly propagating self-sustaining sound waves in air, consisting of a ponderous support having a circular aperture, a light vibratile tympanum having its outer edge mounted on said support, said tympanum being shaped to provide an annular plane adjacant said support and a conical portion springing from the inner edge of said annular plane, and a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum; substantially as described.

15. A sound regenerator for directly propagating self-sustaining sound waves in air consisting of a ponderous support having a circular aperture, a light tympanum mounted upon said support in said aperture, said tympanum having a central conical portion the base of which exceeds in area one-half the effective area of said tympanum; substantially as described.

16. A sound regenerator for directly propagating self-sustaining sound waves in air, consisting of a ponderous

support having a circular aperture, a light vibratile tympanum exceeding nine inches in diameter having its outer edge mounted on said support, said tympanum being shaped to provide an annular plane adjacent said support and a conical portion springing from the inner edge of said annular plane, and a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum; substantially as described.

17. A sound regenerator for directly propagating self-sustaining sound waves in air consisting of a ponderous support having a circular aperture, a light vibratile tympanum mounted in said aperture and having its outer edge secured upon said support, said tympanum being shaped to provide an annular plane adjacent said support and a conical portion springing from the inner edge of said annular plane, the diameter of the base of said conical portion being substantially eight-tenths of the diameter of the said circular aperture in said support, and a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum; substantially as described.

18. A sound regenerator for directly propagating self-sustaining sound waves in air consisting of a ponderous support having a circular aperture, a light vibratile tympanum mounted in said aperture and having its outer edge secured to said support, said tympanum being shaped to provide an annular plane adjacent said support and a conical portion springing from the inner edge of said annular plane, the altitude of said conical portion being substantially one-quarter of the diameter of its base, and a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum; substantially as described.

20. A sound regenerator for directly propagating self-sustaining sound waves in air consisting of a ponderous support having a circular aperture exceeding nine inches in diameter, a light vibratile tympanum mounted in said aperture and having its outer edge secured to said support, said tympanum being shaped to provide an annular plane adjacent said support and a conical portion springing from the inner edge of said annular plane, the diameter of the base of said conical portion being substantially eight-tenths of the diameter of the said circular aperture in said support and the altitude of said conical portion being substantially one-quarter of the diameter of its base, and a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum; substantially as described.

21. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, and a style holder carried by one of said levers; substantially as described.

22. In a sound regenerating machine, a vibration transmission comprising two ponderous members, guides for maintaining the relative positions of said members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, and a style holder carried by one of said levers; substantially as described.

15. 22 19

23. In a sound regenerating machine, a vibration transmission comprising two ponderous members, guides for maintaining the relative positions of said members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, and a style holder carried by one of said levers; substantially as described.

16. 23 20

24. In a sound regenerating machine, a vibration transmission comprising two ponderous members, a vertical fulcrum on one of said members, a horizontal fulcrum on the other of said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, and pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension; substantially as described.

17 22 21

25. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, a style-holder carried by one of said levers, a direct sound regenerating tympanum connected to another of said levers and a pivoted support for said transmission and said tympanum; substantially as described.

25 24

26. 16. In a sound regenerating machine, a vibration transmission comprising a support, two ponderous members carried by said support, one of said members being movable upon said support, insulating material between said movable member and said support, fulcra carried by said members, an articulate parallelogram of links and levers, said levers being mounted on said fulcra and pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension; substantially as described.

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27. In a sound regenerating machine, a tensioned vibration transmission, a style-holder upon one end of said transmission and an untensioned tympanum connected with the opposite end of said transmission; substantially as described.

27

28. The combination of a direct sound regenerating machine and a bottomless cabinet therefor, having apertures on all sides affording substantially free paths for the sound waves from the regenerator-containing cavity of the cabinet to the surrounding atmosphere; substantially as described.

19. 28 23

29. In a direct sound regenerating machine, the combination of a bottomless cabinet having apertures on all sides and a horizontal partition therein, a record holder mounted upon and above said partition, a motor for driving said record holder, a right angle transmission support mounted to swing upon horizontal and vertical axes upon said partition adjacent the periphery of said record holder, one arm of said support adapted to be swung over said record holder, and the other arm of said support extending downwardly through said partition, a vibration transmission ~~support~~ mounted within and insulated from said transmission support and comprising two ponderous members carrying fulcra,

a parallelogram of links and levers, said levers mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, a style-holder carried by one of said levers at the outer end of said transmission support, a spider mounted upon said transmission support below said partition, a ponderous tympanum support carried by said spider, a direct sound regenerating tympanum mounted upon said ponderous tympanum support, said tympanum being of light vibratile material and having a conical form throughout the greater part of its area and a ~~xxxxxxxxx~~ positive connection between the apex of the conical portion of said tympanum and the inner end of the parallelogram of the said vibration transmission; substantially as described.

Insert A3
No. 20 to 27

(X)

90

IN TESTIMONY WHEREOF I affix my signature, in presence of two witnesses.

Witnesses

M. A. Bill
Leon A. Rosenthal

Marcus C. Hopkins

OATH.

Filed 6100

STATE OF NEW YORK,
COUNTY OF NEW YORK. } ss:

MARCUS C. HOPKINS

the above-named petitioner, being duly sworn, deposes and says that he is a citizen of the United States, and resident of Jersey City, County of Hudson and State of New Jersey,

and that he verily believes himself to be the original, first and sole inventor of the improvement in

SOUND REGENERATING MACHINE

described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application; and that no application for patent on said improvement has been filed by him or his representatives or assigns in any country foreign to the United States.

Marcus C. Hopkins

Subscribed and sworn to before me this 12th day of July 1913.

Filed 6500

M. A. Bill
(Signature of Notary Public.)

Div. 23 Room 379 — 2-930 — 167 — Paper No. 2-Rej.

Address only "The Commissioner of Patents, Washington, D. C."

All communications respecting this application should give the serial number, date of filing, and title of invention

JHY-Sut.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON Sept. 9, 1913.

Pennie, Davis & Goldsborough,

#35 Nassau St.,

New York, N. Y.

U.S. PATENT OFFICE, SEP 9 1913 MAILED

Please find below a communication from the ***EXAMINER*** *in charge of the application of*

Marcus C. Hopkins, for Sound Regenerating Machine, filed July 14, 1913, serial number 778,826.

E. B. Moore.

Commissioner of Patents.

In the preamble, line 5, a should follow "in".

The matter of the first page of the specification is objected to as lacking in clearness and inaccurate in part. It is not clear what applicant means in the first paragraph, but if he means that a sound box without the aid of a horn will not produce audible sound waves he is clearly wrong. Atention is directed to the common form of phonograph wherein ear-tubes of uniform diameter lead directly from the sound box. What does applicant mean by "self-sustaining sound waves"? The matter of line 15, and to "air" line 16, is objected to as incorrect. What does applicant mean by "high tension disturbances"?

e''' is e'' on figure 1. g'' is g' on figure 8.

Page 8, lines 7 and 8, why are no wave motions set up in the thin material of the cone?

A formal preamble to the claims should be inserted at the end of page 14.

Claims 1, 2 and 3 are rejected on Miller, June 20, 1905, 793,013, (181-3) or Simon, English patent, July 5, 1904, 15060, (181-3) figure 2. Any graphophone or grammphone of which the examiner

is aware is a "direct sound regenerating machine" within the ordinary import of the terms used.

Claim 4 is objectionable as claiming the insulation, matter not shown on the drawing. See rule 50.

Claim 4 is rejected on any cabinet talking machine in view of Aiken, Sept. 5, 1911, 1,002,479, (181-9) or Hough's English patent, April 16, 1907, 8833 (181-2).

Claim 5, line 3 "compartment" should be compartments.

Claim 5 is rejected on Shanks, May 29, 1906, 822,024, (181-3), Amet, June 23, 1896, 562,753, (181-7), Amet , June 23, 1896, 562,694, (181-7), Repp, Sept. 19, 1911, 1,003,655, (181-7) or Lumiere, Mar. 14, 1911, 986,477, (181-11), figure 7,mounted in any conventional cabinet as Skiff, Mar. 15, 1904, 754,508, (181-3), no invention being found in separating the record and diaphragm spaces by a partition, especially in view of Shields, June 12, 1900, 651,515, (181-2) or Welton, French patent, Feb. 1, 1906, 362,926, (181-3).

Claim 9 is rejected on Repp or Lumiere cited; also as met in terms in Dyer, Dec. 31, 1912, 1,049,215,(181-5), Pumphrey, May 14, 1912, 1,026,178,/(181-3) or Macdonald, May 10, 1910, 957,694, (181-3)

Claim 11, line 5, and should follow"arm."

Claim 11 is rejected on Sheble et al, May 3, 1910, 957,004, (181-3), 15 and 10 being the two arms.

Claim 12 is rejected on Rosenthal, English patent, Nov. 17, 1909, 26,738, (181-3)

Claim 15 is rejected on Kraemer, June 9, 1908, 890,142. (181-11).

Claim 16 is rejected on Kraemer; English, June 10, 1913,

778-826-----3

1,064,062, (181-11); Edison, Feb. 22, 1910, 950,226, (181-10); Stroh, English patent, Feb. 16, 1901, 3393, (181-10); Brown, English patent, Jan. 16, 1911, 1157, (181-11) or Gaumont & Co. French patent, April 15, 1903, 331,326, (181-10).

Claim 17 is rejected on Kraemer. The size of the diphragm is not a patentable limitation.

Claim 18 is rejected as not sufficiently distinguished from Kraemer.

Claims 19 and 20 are rejected on Gaumont in view of Kraemer. Note the dimensions of the diaphragm in figure 2 of Gaumont. No invention is found in providing Gaumont's device with a contact piece as at 16 in Kraemer.

Claim 21, line 6, "member" should be members.

Claim 22, line 3, "position" should be positions.

Claim 24, line 5, "lever" should be levers.

Claim 27 is rejected on Gleason, Aug. 11, 1908, 896,006, (181-11-, figure 9, Johnson, Sept. 3, 1907, 865,105, (181-11) figure 5, or Gleason, April 16, 1907, 850,883, (181-11).

Claim 28 is rejected on Simon, Rosenthal or Miller, no invention being displayed over these structures.

L.H.S.

J. F. Kratton
Ex

U.S. PATENT OFFICE
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DIV 23 PAPER NO. 3

A

Div.23, Room 379,
Application of
Marcus C. Hopkins,
Sound Regenerating Machine,
Filed July 14, 1913,
No. 778,826.

New York City, N.Y., Dec. 5, 1913.

To the Commissioner of Patents:

Sir:

Replying to the office action of September 9, 1913, please amend the above entitled case as follows :-

In the preamble, line 5, insert "a" after "in".

In Fig.1 of the drawing, make "e'' " "e''".

In Fig.8 of the drawing, change "g'" to "g'' ".

At the end of page 14 insert:-

Having thus described my invention, what I claim and desire to secure by letters patent, is:-

Insert commas in the following places on page 1: line 2, after "sounds"; line 5, before "as"; line 9, after "trumpet"; line 16, before "and"; line 17, before "and"; line 18, after "piece"; line 19, after "waves"; line 21, after "reproducer"; line 23, a fter "disturbances"; line 24, after "air"; line 26, after "losses"; line 28, after "action"; line 29, after "tension"; and in the following places on page 2;- line 4, after"record"; line 5, after "air"; line 7, after "reproducer" and after "trumpet"; line 8, after "sounds"; line 10, after "making"; line 17, after "record"; line 19, after "transformer"; line 21, after "regenerator"; line 22, after "invention"; line 23, after "air"; line 25, after "record"; line "26, before

on page 3, as follows;- line 4, before "which"; line 6, after "sounds" and line 11. before"without".

Page 2, line 24, insert a semi-colon before "and".

Page 3, insert semi-colons after "air" in line 7 and after "function"in line 8.

Page 1, line 4, after "propagation" insert "in free air, from a record,".

Page 1, line 5, cancel "in air from a record".

Page 1, line 7, cancel "which would not be propagated as sound".

Page 1, line 17, after "and" insert "which".

Page 1, line 18, after "dissipated " insert "in heat or".

Page 1, line 19, after "waves" insert "of small volume and high tension".

Page 1, lines 19 and 20, cancel "or in heat, as is at once apparent" and substitute "at any considerable distance".

Page 1, lines 21 and 22, cancel "it would appear that".

Page 1, line 26, after "and" insert ", therefore,".

Page 2, line 1, substitute "having" for "with".

Page 2, line 17, cancel "comparatively unknown" and substitute "not obtained".

Page 2, line 18, cancel "or" and substitute "and without".

Page 2, line 23, cancel "the", first occurance, and substitute "unconfined".

Page 2, line 24, cancel "as such".

Page 2, line 25, change "vibration" to"vibrations".

Page 2, line 27,substitute"such a" for "a proper". and insert "as" after "tension".

Page 2, last line, change "to" first occurrence, to "in".

Page 3, line 2, after "wear" insert "of the record".

Page 3, line 6, before "imparting" insert "of".

It is believed that the foregoing amendments eliminate the reasons for objection as to lack of clearness and as to inaccuracy.

With reference as to what is meant on page 1 by "self sustaining sound waves", and by "high tension disturbances", it is pointed out that in ordinary phonographs or talking machines, a small diaphragm is mounted in a sound box containing a very small amount of confined air, and all of the energy of the record is projected against this small diaphragm, which is thus violently vibrated, thereby producing air disturbances of so high a tension, that these disturbances cannot, owing to the inertia of air, effect a movement of a sufficient volume of air to produce sound waves, which, after their production, will be self sustaining so as to carry to a considerable distance and produce sounds which correspond in character, timbre, volume and pitch ~~corresponding~~ to the original sounds which made the record, and which, therefore, are the original sounds regenerated.

Inasmuch as these high tension disturbances, which are produced by the small diaphragm in the confined air space of the sound box, cannot, owing to the inertia of air, produce sound waves of large area and of sufficiently low tension suitable for the sound conductivity of air, such sound waves will not be produced as correspond to the sounds which made the record. On the contrary, these high tension disturbances produced by the diaphragm will be squeaky, will have relatively high pitch, and will not be self sustaining so as to carry to any appreciable distance. It is for this reason that the horn or trumpet

is employed to effect a lateral control of these high tension disturbances, resist their transformation into heat and convert them into waves of sufficiently low tension and large volume to enable them to overcome the inertia of the air and thereby become self sustained.

But the use of the horn or trumpet amplifies the distortions produced by the small diaphragm being so violently agitated , and introduces distortions due to vibrations set up in the horn itself. The resultant sound waves are not true reproductions of the original sounds, but are the characteristic sounds known as "phonograph sounds."

In order to obtain faithful reproduction of the original sound waves , that is, to really regenerate the original sounds, applicant has provided a sound regenerating machine which dispenses with the employment of a horn or trumpet for transforming high tension disturbances into waves of lower tension, and in which the vibration of the stylus by the record are mechanically directly transmitted to a diaphragm which is free to vibrate in unconfined air, which has sufficient area to set in motion a large volume of air, which is sufficiently light and rigid to enable it to move in synchronism with the stylus, and the distance of vibration of which is sufficiently short to permit of a relatively slow movement appropriate for the sound conductivity of air, whereby the regenerated sounds will be self sustaining and will be accurate reproductions of the original sounds.

Applicant has thus produced a machine in which the sounds are regenerated directly from the record and in open and unconfined air, without the intervention of a sound box and its confined body of air, and without the intervention of any vibration transforming device, such as a

horn or trumpet.

So far as applicant is aware the machine of this invention is the first which has ever been constructed which will accurately regenerate the original sounds without distortion, without squeaking, without accentuation of notes of certain pitch, without change in intonation and without any appreciable loss of energy, and which in fact will produce faithful reproductions of the original sounds.

With reference to the statement in lines 7 and 8 of page 8 that no wave motions are set up in the material of the cone portion of the diaphragm, it will be noted that the lower end of the rod V is rigidly secured to the cap M which is secured to the apex of the cone L. The vibrations which are imparted to the cone L through the rod V are mechanical movements which are transmitted directly from the stylus by the levers Q and R and the rods S and S'. The cone L is therefore moved bodily to and fro and is not molecularly vibrated, the diaphragm not being under tension, as are the transmission rods just referred to. The examiner, of course, understands that the sides of a cone being straight, will not yield when a blow strikes the apex of the cone in the direction of the axis thereof. If the diaphragm were flat where it is connected to the rod V, there would be a local vibration set up in the immediate vicinity of the connecting rod, but a large part of the diaphragm would not be bodily moved, as is the case with the cone, and the resultant sounds would be very feeble, and would not compare in volume to thesounds which are produced by the cone of the applicant's machine. Applicant has demonstrated this practically by employing both flat and conical diaphragms.

With reference to claims 1, 2 and 3 which have been rejected on the patent to Miller No. 793,013,or on the patent (British) to Simon, it will noted that each of these devices has a small diaphragm located in a sound box provided with a horn and is not a direct sound regenerating machine, in which the regenerated sounds are effected without the intervention of a transforming trumpet or horn , as in applicant's structure.

With machines having sound boxes and horns, it is not material that the cabinet has apertures on all sides, as set forth in claim 1;nor whether it has no bottom as set forth in claim 2. On the other hand it is of great importance that the cabinet,which contains a direct sound regenerating machine having a diaphragm which impresses its vibrations upon unconfined air, shall have an aperture leading to the surrounding atmosphere, as in claim 3; having no bottom as in claim 2, or having apertures on all sides serving for free path for the sound waves from the compartment containing the regenerator to the surrounding atmosphere, as in claim 1. In machines having sound boxes and horns it is only required that the horn communicate with the outside atmosphere.

The references do not disclose any direct sound regenerating machine mounted in a cabinet, so that it is believed that the patent to Aiken, No. 1,002,479, or the British patent to Hough,No. 8833, of 1907, which show insulation between a machine and a table, the machines being of the ordinary sound box type do not apply to claim 4, which combines a direct sound regenerating machine with a cabinet in which the machine is mounted and from which it is insulated.

As to claim 5,the provision of a partition between the record table and the tympanum effects a variety of

functions. It provides a support for the machine, serves as a guard for the protection of the diaphragm , which in a machine of this character must be large, exposed to the open air and is liable to injury. At the same time it serves the commercial purpose of enabling a user of a the machine to readily put on or take off a record without danger of injury to any of the delicate parts. In the ordinary sound box machine the diaphragm is protected, is close to the record and requires no supporting and protecting partition. None of the references discloses a record table and transmission arm in one compartment and a tympanum located in the other compartment, as specified in claim 5. In the French to Welton, No. 362,926 and the patent to Shields, No. 651,515, cited to show a partition separating ~~the record and~~ the record table and the diaphragm, the record and the diaphragm are both in the same chamber. In neither one of these devices is there any partition between the record table and the tympanum, All that these two devices show,with reference to a partition is a trumpet leading from one chamber to the outside thereof.

Cancel "compartment" and substitute "compartments" in line 3 of claim 5. Insert a comma before "of" in line 2 of said claim.

Cancel claim 9.

Claim 10, line 1 insert a comma after"machine". Insert a comma after "support" in line 3.

Claim 11,insert a comma after"machine"line 1, and after "holder", line 2. Line 5 after "and" insert "adapted to carry a stylus, the support having". Same line,before " a tympanum" insert"and" Same line cancel "by" and substitute "at the free end of".

Claim 11, as amended, distinguishes from the patent to Sheble et al, cited, in being restricted to a direct sound regenerating machine, with the diaphragm carried at the free end of the second arm, while in the reference the diaphragm is carried at the junction between the arms and the machine is of the sound box type having a transforming horn.

The British patent to Rosenthal No. 26, 738 is not a direct sound regenerating machine, as specified in claim 12 but is a sound box machine having a horn, which closes an opening in the bottom of the cabinet and the tympanum is not directed downwardly as in applicant's construction. In the reference the diaphragm is not free to vibrate in the open air and direct sound waves unrestricted and without transformation through an opening in the bottom of the cabinet.

Each of the claims 15 to 20 inclusive is drawn to the combinations of elements therein set forth as combined in a sound regenerator for directly propagating self sustaining sound waves in air. Each of the devices of the references is an ordinary reproducer having a small diaphragm operating in a sound box having a small volume of confined air, and requiring, in order to set up self sustaining waves, the intervention of a transforming device, such as a horn or trumpet, to change the high tension vibrations into lower tension waves of greater amplitude. No one of the diaphragms described and illustrated in the said references can be employed to directly propagate and regenerate the original sounds, but ,the sounds produced therewith will be of high pitch and of so great a tension that the disturbances will not set up self sustaining waves in the air , for the reasons hereinbefore given.

For these reasons the references cited against claims 15 to 20 inclusive do not meet the claims. With reference to claims 17 which specifies a tympanum exceeding 9 inches in diameter, it is submitted that the size of the tympanum is what enables it to effect direct regeneration of the sound. When a horn is employed for transforming high tension disturbances, the size of the tympanum is immaterial. Applicant has practically demonstrated that, to effect direct regeneration from the record of the sounds, a light, vibratile tympanum of substantially 9 inches in diameter or greater must be employed in order to obtain faithful reproductions. With respect to claim 15, there is no apex to the diaphragm of Kraemer, No. 390,142, the plate 16, Fig.3, being secured to the flat central portion of the diaphragm, which is not a cone as in applicant's construction, but is a frustum of a cone with a flat top, which is considerably larger than the metal plate 16. With a diaphragm of this kind , the center will yield and produce local disturbances. Furthermore the conoidal portion of the Kraemer device, not terminating in an apex, and the plate 16 not reaching to the conoidal portion , said conoidal portion will not be moved bodily to the same extent as would be the case if the metal plate were secured to an apex, as in applicant's construction.

As has already been pointed out, the Kraemer device is a sound box employing a horn and cannot directly regenerate self sustaining sound waves without the employment of the trumpet, while claims 15 to 20 inclusive are drawn to a direct sound regenerator.

Claim 18 distinguishes from Kraemer in the same manner as does claim 15, the cap being secured to the apex of a cone, while in the Kraemer device the cap is secured to the flat top of the frustum of a cone, the top being

of greater diameter than the cap.

Claims 15, 17, 18, 19 and 20 each distinguishes from Kraemer in the cap being secured to the apex of a cone.

The dimensions of the diaphragm and of the conical portion thereof, as set forth in claims 15 to 20 inclusive, are essential elements in a direct sound regenerator, but they are not essential in sound boxes which employ horns or trumpets as do all of the references which have been cited against these claims. This has been demonstrated by the applicant by actual trial.

For the foregoing reasons it is submitted that claims 15 to 20 inclusive are not met by the references.

Claim 16, line2, change "og" to "of".

Claim 21, line 6, change"member" to "members".

Claim 22, line 3, change"position" to "positions".

Claim 24, line 5, change "lever" to "levers".

Claim 26, last line, change "tention" to "tension".

Claim 27 distinguishes from the references in being drawn to a structure having an untensioned diaphragm, while the devices of the references have tensioned diaphragms as set forth in lines 15 to 18, page 1 of the Gleason patent, No. 850,883. Claim 27 further distinguishes in the untensioned diaphragm being connected at the end of the tensioned transmission, while in the references the diaphragm is connected intermediate of the ends of the tensioned members.

In the Gleason and Johnson patents, the tension serves only to retain the knife edges seated, and the tension serves to resist the vibration of the stylus. In applicant's structure, the tension does not interfere at all with the free vibration of the stylus, but is in a direction parallel with the direction of movement of the stylus. For this reason the tympanum is connected at one end of the

tensioned transmission, in applicant's structure, instead of intermediate of and at right angles to the direction of tension as in the devices of the references.

With reference to claim 28 rejected on Simon, Miller or Rosenthal, it will be noted, as was stated with reference to claims 1 to 3, that the references are all sound box machines which require horns to regenerate the sound waves, and in such structures it is not material whether or not the cabinet is bottomless and has apertures in all of its sides for affording free paths for sound waves to the surrounding atmosphere, as set forth in claim 28, but it is of importance in a direct sound regenerating machine, for the success of such a machine is dependent upon the free vibration of a large diaphragm in unconfined air.

Furthermore, none of the references is provided with a bottomless cabinet nor with apertures on all sides, as set forth in the claims. Simon's machine rests on a table or base, and is not provided with any cabinet. The cabinets of Rosenthal and Miller have no openings on all sides, and each has a bottom provided with an opening which is closed by a horn.

Relative to the criticism in connection with claim 4, that the drawings do not illustrate insulation between the regenerator and the cabinet, attention is directed to Fig.3, in which there is shown insulation i' between the regenerator and the cabinet.

For the foregoing reasons favorable reconsideration of the rejected claims is requested.

Change the ordinals of claim 10 and the claims following.

20. Please add to the claims the following claims :-

24 "30. In a sound regenerating machine, a tympanum, a vibration transmission tensioned in the direction of its vibration independently of the tympanum and connected therewith, and a style holder connected with said transmission.

25 "31. In a sound regenerating machine, an untensioned tympanum, a vibration transmission tensioned in the direction of its vibration and connected with said tympanum, and a style holder connected with said transmission .

26 "31. In a sound regenerating machine, a tympanum, an oscillatory transmission member connected therewith, a style holder for oscillating the transmission member, and means independent of the tympanum for tensioning the transmission member in the direction of its oscillatory movement.

27 23 "32. In a sound regenerating machine, a tympanum, an oscillatory transmission member connected therewith, a style holder for oscillating said member, and means independent of the tympanum for yieldingly imparting a tension to said member in the direction of its oscillatory movement .

28 "33. In a sound regenerating machine, an untensioned tympanum, a transmission member connected therewith and adapted for oscillation, a style holder for oscillating said member, and means for imparting a tension to said member in the direction of its oscillatory movement

24.

cl. 25 follows

"34. In a sound regenerating machine, a tympanum, an oscillatory transmission member connected therewith, a style holder for oscillating said member, and means for tensioning said member without affecting its freedom of movement ."

"35. In a sound regenerating machine, a style holder, a tympanum, and transmission means under tension connecting the style holder and tympanum, the freedom of movement of the style holder being unaffected by said tension."

"36. In a sound regenerating machine, an oscillatory style, a tympanum, and longitudinally rigid transmission means connecting the style and tympanum and arranged to impart to the tympanum vibrations which have less length than the vibrations of the style."

"37. In a sound regenerating machine, an oscillatory style, a tympanum, and tensioned transmission means connecting the style and tympanum and arranged to impart vibrations to the tympanum which have less length than the vibrations of the style."

"38. In a sound regenerating machine, an oscillatory style, a tympanum, and tensioned transmission means connecting the style and tympanum and arranged to impart vibrations to the tympanum having less length than the vibrations of the style, the tension of the transmission being in the direction of its vibration."

"39. In a sound regenerating machine, a tympanum having a free area exceeding nine inches in diameter and having a portion substantially eight-tenths of the diameter of said free area which is rigid in the direction of the axis of the tympanum."

"40. In a sound regenerating machine, a tympanum having a free area exceeding nine inches in diameter and having a central portion substantially eight-tenths of the diameter of said free area."

~~41.~~ In a sound regenerating machine, a tympanum having a free area exceeding nine inches in diameter and having a conical portion substantially eight-tenths of the diameter of said free area, the altitude of said conical portion being substantially one-quarter of the diameter of its base."

"42. In a sound regenerating machine, an oscillatory style, a tympanum having a relatively rigid vibratory portion, and longitudinally rigid transmission means connecting the style and the rigid portion of the tympanum and arranged to impart vibrations thereto having less length than the vibrations of the style."

"43. In a sound regenerating machine, an oscillatory style, a tympanum having a conical vibratory portion, and transmission means connecting the style with said conical portion and arranged to impart thereto vibrations having less length than the vibrations of the style."

"44. In a sound regenerating machine, a style holder, a tympanum having a relatively rigid vibratory portion, and a tensioned transmission connecting the style holder with said rigid portion, the freedom of movement of the style holder being unaffected by the tension of the transmission.

"45. In a sound regenerating machine, a style holder, a tymparum having a conical vibratory portion, and a tensioned transmission connecting the style holder and said conical portion, the freedom of movement of the style holder being unaffected by the tension of the transmission."

~~46.~~ In a sound regenerating machine, a style holder, a tympanum having a rigid vibratory portion, and a tensioned transmission connecting the style holder with said rigid portion, the tension of said transmission being in the direction of its vibration and independant of the tympanum.

"47. In a sound regenerating machine, a style holder, a tympanum having a conical vibratory portion, and a tensioned transmission connecting the style holder with said conical portion, the tension of said transmission being in the direction of its vibration."

"48. In a sound regenerating machine, a style holder, an untensioned tympanum having a rigid vibratory portion, and a tensioned transmission connecting the style holder with said rigid portion."

"49. In a sound regenerating machine, a style holder, an untensioned tympanum having a conical vibratory portion, and a tensioned transmission connecting the style holder with said conical portion."

"50. In a sound regenerating machine, a style, a tympanum, and longitudinally rigid transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style."

"51. In a sound regenerating machine, a style, a tympanum , and tensioned transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style."

"52. In a sound regenerating machine, a style, a tympanum, and tensioned transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style, the tension of said transmission being in the direction of its vibration."

"53. In a sound regenerating machine, a style, a tympanum, and tensioned transmission means connecting the style and tympanum, and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style, the tension of said transmission being independent of the tympanum."

"54. In a sound regenerating machine, a style, a tympanum, and tensioned transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style, the tension of said transmission being in the direction of its vibrations and independent of the tympanum."

"55. In a sound regenerating machine, a style, an untensioned tympanum, and transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style."

"56. In a sound regenerating machine, a style, an untensioned tympanum, and tensioned transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style."

"57. In a sound regenerating machine, a tympanum having a conical vibratory portion adapted to be vibrated from a record, the tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from the record of sound waves of relatively large volume and carrying power."

"58. In a sound regenerating machine, a style, a tympanum and longitudinally rigid transmission means connecting the style and tympanum and having means for impart-

ing vibrations to the tympanum having no greater length than the vibrations of the style, the tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration of sound waves of relatively large volume and carrying power."

"59. In a sound regenerating machine, a style, a tympanum, and longitudinally rigid transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having less length than the vibrations of the style, the tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration of sound waves of relatively large volume and carrying power."

"60. In a sound regenerating machine, a tympanum having a rigid vibratory portion adapted to be vibrated from a record, the tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from the record of sound waves of relatively large volume and carrying power, and longitudinally rigid means connected with said rigid portion for transmitting thereto vibrations of a style."

"61. In a sound regenerating machine, a tympanum having a conical vibratory portion adapted to be vibrated from a record by a style, the tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from the record of sound waves of relatively large volume and carrying power, and transmitting means connected with said conical portion and adapted to be actuated by a style."

"62. In a sound regenerating machine, a tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from a record of sound waves of relatively large volume and carrying power, and tensioned vibration transmitting means connected to the tympanum and adapted to be actuated by a style, the tension thereof not extending to the tympanum."

"63. In a sound regenerating machine, a tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from a record of sound waves of relatively large volume and carrying power, and tensioned vibration transmitting means connected to the tympanum and adapted to be actuated by a style, the tension of the transmission being in the direction of its vibration and not extending to the tympanum.

"64. In a sound regenerating machine, a tympanum having a rigid vibratory portion, the tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from a record of sound waves of relatively large volume and carrying power, and tensioned vibration transmitting means connected to said rigid portion and adapted to be actuated by a style, the tension thereof not extending to the tympanum."

"65. In a sound regenerating machine, a tympanum having a conical vibratory portion and having a vibratile area of sufficient size to effect, without amplification, the regeneration from a record of sound waves of relatively large volume and carrying power, and tensioned vibration transmitting means connected to said conical portion and adapted to be actuated by a style."

"66. In a sound regenerating machine, a style holder having an axis which, when the style carried thereby is in operative contact with the record, is substantially perpendicular to the record."

"67. In a sound regenerating machine, a style holder having an axis which, when the style carried thereby is in operative contact with the record, is substantially perpendicular to the record, the style holder having means for holding the style at an inclination to the axis."

Claims 29 to 33 and 38, 46, 47, 52, 54 and 63 distinguish from the references in the tension of the transmission being in the direction of the vibration thereof. By this construction the freedom of movement of the transmission by the style is not affected. In the devices of the Gleason and Johnson, cited as showing tensioned transmission the tension is in a direction transverse to the vibrations of the style. It will be understodd that in such constructions the tension of the transmission resists free movement of the style.

Claims 34, 35, 44, 45, 46 ~~xxx xx xx xx~~ inclusive distinguish from the references in the feature of the tension of the transmission means not interferring with the free movement of the style. As above stated, the tension of the Gleason and Johnson devices does interfere with the free movement of the style.

Claims 30, 33, 48, 49, and 56 distinguish from the references in the combination with a tension transmission of an untensioned tympanum. In the references having tensioned transmission, the tympanum is tensioned thereby.

Claims 31, 32, 46, 53, 54, 62, 63 and 64 distinguish from the references in the tensioned transmission which does not extend to the tympanum. This is also true of claim 29.

Claims 36, 37, 38, 42, 43 distinguish from the references in the arrangement by which the tympanum has a less length of vibration than the style. In the references the leverage is the other way, the style holder being pivoted with the style at the shorter end of the lever, whereby the length of vibration of the diaphragm is greater

than the length of vibration of the style. This makes great wear on the record and distorts the sound waves.

With small diaphragms, such as are used in sound boxes, a large amount of vibration is imparted to the diaphragm to compensate for the small amount of air moved. Such a large movement of the diaphragm produces high tension disturbances due to the rapid movement of the diaphragm in its traveling the distance which it is required to travel during each vibration. The inertia of the air prevents its partaking bodily of these high tension disturbances so it becomes necessary to confine them and transform them, by means of a trumpet, into waves of less tension and larger volume to which the air can respond and thereby produce waves of large volume and carrying power and which are self sustaining.

Applicant eliminates the production of high tension disturbances which require transformation by a horn, and employs a diaphragm having a vibratile area of sufficient size and small range of movement to effect, when vibrated, the regeneration directly, without amplification, and without the use of a horn or sound box, waves which are self sustaining by reason of their large volume and carrying power. The employment of a large diaphragm moved but a small distance in each vibration reduces the distortions, and permits the style to exert great leverage in vibrating the diaphragm, thereby reducing the wear on the record.

What is meant by "high tension disturbances" may be illustrated as follows:- If a paddle be moved flatwise rapidly back and forth in water, at a rate of speed such that the inertia of the water will not permit it to respond, only violent local disturbances will be produced which will not carry to any considerable distance. On the other hand if the paddle be larger and of considerable area and be

moved back and forth slowly enough for the water to respond, waves of large volume and carrying power will be produced. These two instances, of the use of the small paddle moved rapidly to and fro for a considerable distance and thereby producing only local disturbances, not capable of generating waves of large volume and carrying power; and the use of a large paddle moved a less distance in the same length of time, and therefore more slowly, and generating waves of large volume and great carrying power, are analagous respectively to the small violently agitated diaphragm of the ordinary sound box and horn phonograph, and applicant's structure, which employs a large relatively slow moving and slightly vibrated diaphragm, which vibrates in unconfined air, thus generating sound waves which are"self sustaining", and which eliminates the sound box and horn and the distortions which accompany their use.

Claims 50 to 56 inclusive and 58, 59 and 60 distinguish from the references in the transmission means which imparts vibrations to the tympanum of no greater length than the vibrations of the style.

Claims 39, 40,41, 57 61 and 65 distinguish from the references in the conical tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from the record of sound waves of large volume and carrying power. Each of the references having a conical diaphragm, is of the sound box type having a small tympanum with a range of vibrations greater than that of the stylus and which requires a sound box and horn to transform the high tension disturbances produced into waves to which the air can respond.

Claims 36, 42, 50, 58, 59 and 60 distinguish from the references in the transmission means being longitudinally rigid. This feature is of great importance in direct sound regenerating machines, where the reduction in length of vibration of the tympanum, relative to the stylus, is effected, as specified in the first five of these claims. By having a longitudinally rigid transmission, the vibrations from the style are transmitted to the diaphragm without loss by means of loose joints or by absorption, as would occur with a longitudinally flexible transmission.

Claims 66 and 67 distinguish from the references in the axis of the style holder being substantially perpendicular to the record, when the style is in the operative position on the record. In the references, the axes are either parallel with the surface of the record, or disposed at an inclination thereto. By having the axis substantially perpendicular, the style travels in a plane transversely in the record groove, which is the proper movement, instead of moving in a curve transversely in the record, as it does in the devices of the references.

For the foregoing reasons favorable reconsideration of the rejected claims, and favorable consideration of the new claims is requested.

Annexed hereto find supplemental Oath .

Respectfully submitted,

Parmelee Davis Robertson & Hyde

Attorneys for Marcus C. Hopkins.

SUPPLEMENTAL OATH.

State of New York, :
: ss.
County of New York.:

Marcus C. Hopkins, whose application for letters patent for an improvement in Sound Regenerating Machines, serial number 778,826, was filed in the United States Patent office on or about the 14th day of July, 1913, being duly sworn deposes and says that the subject matter of the foregoing amendment was part of his invention, was invented before he filed his original application, above identified, for such invention, was not known or used before his invention, was not patented or described in a printed publication in any country more than two years before his application, was not patented in a foreign country on an application filed more than twelve months before his application, was not in public use or on sale in this country for more than two years before the date of his application, and has not been abandoned.

Marcus C. Hopkins.

Subscribed to and sworn before me this 22 day of December, 1913.

M. A. Bill

Notary Public for and in
Kings County, New York.
Certificate filed in N.Y. Co.
Notary No. 48.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

LCE-Su WASHINGTON Feb. 7, 1914.

Pennie, Davis and Goldsborough,
35 Nassau Street,
New York, N. Y.

U.S. PATENT OFFICE, FEB - 1914 MAILED.

Please find below a communication from the EXAMINER in charge of the application of

Marcus C. Hopkins, for Sound Regenerating Machine, filed July 14, 1913, Serial No. 778,826.

c e-Su

Thomas Ewing
Commissioner of Patents.

In response to amendment of Dec. 24, 1913.

"e'''" has been changed on Fig. 1 to e''', instead of as directed on page 1 of the above noted amendment.

Page 1, lines 15 and 16, "the ----air" is objected to as not true as broadly as stated, for the reasons of record. What authority has applicant for the use of "high tension" and "low tension" in connection with sound waves?

Claim 1 is rejected on Miller or Simon of record for the reasons of record, as not distinguishing therefrom. "Direct sound regenerating machine" is held to be too vague and indefinite to distinguish from the ordinary talking machine which is broadly such a machine. Nor is invention found in mounting Lumiere of record in a cabinet with provision for sound outlet on all sides, if such is desired.

Claim 2 is rejected on the references and the reasons of record; also as involving no invention in mounting Lumiere in a bottomless cabinet.

Claim 3 is rejected on the references and reasons of record; and also on Lumiere mounted in any conventional cabinet as Skiff et al., of record.

Claims 4 and 5 are rejected on the references for the reasons of record.

Claim 6 is rejected as specifying only

Johnson, 1,015,321, Jan. 23, 1912, (181-3), note 12,

with the end partition extended to separate the record compartment from a sound conduit compartment, as in Shields or Welton of record, or in

German patent, 220,412, Mar. 26, 1910, (181-3).

Claim 7 is rejected as specifying no more than the device in

Persichetti, French patent, 397,609, May 13, 1909, (181-3), with a diaphragm at the mouth of the horn as in

Szek et al., English patent, 8,011, Apr. 3, 1906, (181-27).

Claims 8 and 9 are rejected on Persichetti and Szek, no invention being found in flaring the mouth of the horn in the former as in the latter.

Claim 10 is objectionable in that it is not positively expressed that the second arm has a free end. Claim 10 is rejected on Johnson above cited. 4 and 7 are the two arms. It is patentably immaterial whether 12 is carried by 7 or 8.

Claim 11 is rejected on Rosenthal of record.

Claims 12 and 13 are allowed.

Claim 14 is rejected as no invention is found in interposing any of the common non-vibratile members employed in this art between the diaphragm and stylus bar as in

Kraemer,	883,490,	Apr. 21,	1908,	(181-11),
Montgomery.	652,800,	July 3,	1900,	" "
Hill,	668,183,	Feb. 19,	1901,	(181-10), or
Berliner,	534,543,	" "	1895,	(181-3)

between the diaphragm and stylus bar of any such structures as in Gaumont, English, Edison, Browne, or Stroh, all of record.

Claim 15 is rejected on the references and for the reasons of record.

Claim 16 is rejected on the references and reasons of rejection of claim 14. The size of the diaphragm is held not a patentable limitation. Note, however, that Lumiere discloses a diaphragm exceeding nine inches in diameter.

Claims 17, 18 and 19 are rejected upon Gaumont of record, in connection with the considerations above given.

Claims 20 to 25 inclusive are allowed.

Claim 26 is rejected on the references of record. As the tension means acts in the plane of the bar and in the direction of the fulcrum, it is believed it will not tension the diaphragm in these several structures. This claim is also rejected on

English, 940,795, Nov. 23, 1909, (181-11), note spring 22.

Claim 27 is rejected on the references of record and also on the additional grounds of rejection of claims 1 and 2.

Claim 28, line 5, "angle" should be -angled-. This claim is otherwise allowable.

Claims 29 to 33 inclusive, 46, 54, and 63 are allowable, as at present advised.

Claims 34, 35, 44 and 45 are objectionable as inaccurately descriptive in the statement that the freedom of movement of the stylo holder is unaffected by the tension of the transmission. The friction of the moving parts will obviously be increased with the pressure.

Claims 34, 35 and 44 are rejected on the grounds of rejection of claim 26.

Claims 36 and 55 are rejected on any of the following references:

Edison,	703,774,	July 1, 1902,	(181-10),		
Betzold,	633,226,	Sept. 19,1899,	(181-11),		
Jones,	750,460,	Jan. 26, 1904,	"	"	Figs. 1 to 3,
Schwartz,	875,853,	" 7, 1908,	"	"	or
German patent,	183,685,	Apr. 25, 1907,	"	"	

Claims 37, 51, 53 and 56 are rejected on the references last cited in view of the references cited against claim 26.

Claim 38 is rejected as no invention is found in tensioning the transmission in any of the references cited against claim 36, in view of the cited art. Thus no invention is found in tensioning Jones' stylus bar as in

Berens, 890,754, June 16, 1908, (181-11).

Claims 39, 40 and 41 are rejected on Gaumont or English, 1,064,062, in view of Lumiere, the selection of the particular dimensions being held not a matter of invention in the absence of a showing of novel results arising from the particular dimensions and such as could not be obtained by the ratio of dimensions of the references.

Claims 42 and 43 are rejected on Gaumont or English last cited in view of the references cited against claim 36.

Claim 45 is rejected on any of the references cited against claim 26 in view of any conical diaphragm in the art.

Claim 47 is rejected on any conical diaphragm as in Caumont or English, 1,064,062, in view of any such tension means as in Berens.

Claims 48 and 49 are rejected on any conical diaphragm mounted in the references cited against claim 26.

Claim 50 is rejected on any of the references cited against claim 36 or

Edison, 705,829, July 29, 1902, (181-11).

Claim 52 is rejected on any of the references cited against claim 36, in view of any such tension means as in Berens.

Claim 57 is rejected on Lumiere; also on any conical diaphragm cited in view of Lumiere.

Claim 58 is rejected on the grounds of rejection of claim 57, the longitudinally rigid transmission means being the common form in this art, as in references cited, and no invention being found in actuating any of the cited diaphragms by such means.

Claim 59 is rejected on the references and the reasons last given, no invention lying in using a reducing lever in view of the art cited against claim 36.

Claim 60 is rejected on any conical diaphragm as English, 1,064,062, in view of Lumiere.

Claim 61 is rejected on the grounds given against claim 57.

Claim 62 is rejected on Lumiere in view of any of the references cited against claim 26.

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Claims 64 is rejected on the grounds of rejection of claim 60 in view of any of the references cited against claim 26.

Claim 65 is rejected on the grounds of rejection of claim 64, or on the grounds of rejection of claim 60, in view of any of the tensioning means cited.

Claims 66 and 67 are rejected on

Shue, 842,028, Jan. 22, 1907, (181-11),
English, 1,001,004, Aug. 22, 1911, " " or
Lyons, English patent, 15,675, June 29, 1910, (181-11).

The claims in this case are many times too numerous for the scope of applicant's invention, and should be reduced to not over twenty.

L.H.S.

H. D. Crossbrook, Exr.

Div. 23 - Room 379

FEB 6 1915

UNITED STATES PATENT OFFICE

Application of MARCUS C. HOPKINS,
Filed July 14, 1913,
Serial No. 778,826
SOUND REGENERATING MACHINE.

New York, February 5, 1915.

The Honorable Commissioner of Patents,
Washington, D.C.

S i r :

In reponse to Office Action of February 7th, 1914, please amend as follows:

On page 1 of the specification, line 5, after "waves" insert substantially corresponding to the original recorded sounds in intensity or amplitude as well as in pitch and timbre; lines 11 and 12, cancel "self-sustaining" and substitute - such regenerated. Lines 15 and 16 cancel "self-sustaining" and substitute - such -. In line 19 strike out the amendment inserted after the word "waves", and which reads " of small volume and high tension". In line 20 cancel "high tension" and substitute - relatively violent -. In line 25, after "conducting" insert - such - and after "disturbances" strike out "of such tension". In the last line strike out "tension" and substitute - violence of the disturbances -.

On page 2, in line 1, change "tension" to - movement -. Cancel the last two lines of page 2, and the first two lines of page 3, and substitute - directly in the free air surrounding it sound waves of an intensity or amplitude substantially corresponding to the original recorded sound waves. In other words, the original sounds

are directly regenerated by the vibrating tympanum without the interposition of a restrictive or sound modifying transformer.

On page 6, in the last line, after "portion" insert - or supporting rim - .

On page 7, in line 7, strike out "called for by the correla", and strike out lines 8, 9 and 10, and line 11 through the period, and substitute - which are required to regenerate the sound waves in the manner above described.

On page 8 in the last line, change the comma before "but" to a period, and strike out the remainder of the line, and the first five lines and line 6, through the period, on page 9.

On page 9, in line 10, strike out "It is prob-" and strike out lines 16 to 28 inclusive, constituting the remainder of the paragraph.

Cancel claims 1 to 4, inclusive, and substitute therefor the following:

1. In a machine for directly regenerating sound from a record of the same, a vibratile conical tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

2. In a machine for directly regenerating sound from a record of the same, a vibratile conical tympanum, a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated,

sound waves substantially corresponding in intensity to the recorded sound waves, and an open-work cabinet enclosing the tympanum but affording substantially free access of the surrounding air thereto; substantially as described.

Change the number of claims 5, 6, 7, 8, 9 and 10 to 3, 4, 5, 6, 7 and 8, respectively. Cancel claim 11 and change the numbers of claims 12 and 13 to 9 and 10.

In claim 8, old claim 10, in line 5, after "arm" insert - having a free end -.

Cancel claims 14 to 19, inclusive, and substitute therefor the following :

7. ~~11.~~ In a machine for directly regenerating sound from a record of the same, a tympanum support having a circular aperture, a light vibratile tympanum having its outer edge rigidly mounted in said support, said tympanum being shaped to provide an annular sustaining rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

8. ~~12.~~ In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture, a light tympanum mounted upon said support in said aperture, said tympanum having a central conical portion, the base of which exceeds in area one half the effective area of the said tympanum.

and a mechanical transmission, through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

9. ~~12.~~ In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture, a light vibratile tympanum exceeding nine inches in diameter, having its outer edge rigidly mounted on said support, said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, whereby the tympanum imparts to the surrounding free air sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

10. ~~14.~~ In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture exceeding nine inches in diameter, a light vibratile tympanum mounted in said aperture and having its outer edge rigidly secured upon said support, said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the diameter of the said circular aperture in said support, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations

produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

11. ~~18.~~ In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture, a light vibratile tympanum mounted in said aperture, and having its outer edge secured to said support, said tympanum being shaped to provide ~~an annular rim adjacent said support, and a conical por-~~ tion springing from the inner edge of said annular rim, the altitude of said conical portion being substantially one fourth of the diameter of its base, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

12. ~~16.~~ In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture exceeding nine inches in diameter, a light vibratile tympanum mounted in said aperture, and having its outer edge secured to said support, said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths

of the diameter of said circular aperture in said support, and the altitude of said conical portion being substantially one quarter of the diameter of its base, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, whereby the tympanum imparts to the surrounding free air sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

Change the numbers of allowed claims 20, 21, 22, 23, 24 and 25 to 17, 18, 19, 20, 21 and 22 respectively.

Cancel claims 26 and 27. Change the number of claim 28 to 23, and in line 5 change "angle" to - angled -.

Change the numbers of allowed claims 29, 30, 31, 32 and 33 to 24, 25, 26, 27 and 28.

Cancel claims 34, 35, 36, 37 and 38. Change the numbers of claims 39, 40 and 41 to 29, 30 and 31. Cancel claims 42, 43, 44 and 45. Change the number of allowed claim 46 to 32. Cancel claims 47 to 53 inclusive. Change the number of allowed claim 54 to 33.

Cancel claims 55 to 62 inclusive. Change the number of allowed claim 63 to 34. Cancel the remaining claims and substitute:

28. ~~31~~ ~~35.~~ In a sound regenerating machine, a tensioned vibration transmission, a style-holder upon one end of said transmission and an untensioned tympanum connected with the opposite end of said transmission, the tension of the transmission being in the direction of its vibration; substantially as described.

REMARKS

The specification has been amended, and many of the claims have been cancelled, without prejudice, to reduce the number of claims, in deference to the Examiner's suggestion. Other claims have been redrawn to express more clearly the essential novelty of applicant's invention.

New claims 1 and 2 will, perhaps, bear upon their faces the distinguishments relied upon, but they will hereinafter be discussed in connection with the redrawn claims numbered 11 to 16.

Reconsideration of claims now numbered 3 to 8, inclusive, is respectfully requested.

Claim 3 is rejected on Shanks and Amet, No. 562, 753 and No. 562,694; Rep No. 1,002,655, and Lumiere, in view of Skiff, Shields and Weeton. We do not find in any one of these patents a cabinet having two compartments, one of which contains a record tablet and the other a tympanum with a transmission arm extending from one compartment to the other. We are at a loss to understand why the Examiner says there is no invention in this arrangement. As pointed out, the cabinet, having a partition between the record tablet and the tympanum, effects a variety of functions, which are enumerated in the argument filed December 24, 1913. In the absence of such a construction in the prior art, we respectfully submit that the claims should be allowed.

Claim 4 contains the limitation that the transmission arm swings on one side of the partition and the tympanum is mounted upon the transmission arm and swings upon the other side of the partition. We do not understand how the patent to Johnson has any bearing upon this claim. Where

is the partition upon which the transmission arm is supported and through which it extends? In the German patent the tympanum, which is in the small reproducer, is immediately above the record tablet, and we do not see any partition through which the transmission arm extends, or, indeed, any transmission arm at all.

With respect to claim 5, we do not see that Persichetti shows any partition at all, much less a transmission arm extending downwardly through such a partition and carrying a tympanum there beneath, and the same remark applies to Szek British patent.

With respect to claims 6 and 7, we ask for further application of the references or an allowance. We do not understand what relation the flaring of the mouth of the horn in Persichetti would have to these claims, which call for a particular cabinet structure and arrangement, including a transmission arm swinging over the record support and a tympanum carried by the arm and extending under the record support. So far as we can see the references cited against this group of claims have no relation to the invention herein disclosed. The differences are so great that there can be no objection to defining them but it seems to us that they are defined in the claims as now presented.

Claim 8 falls with the group just discussed, and the Examiner is asked to specifically apply the Johnson reference.

We respectfully solicit a careful consideration of the new claims 11 to 16 inclusive, which have been redrawn, following somewhat the form of new claims 1 and 2, to define a tympanum of such area as to produce directly regenerated sound waves substantially corresponding in intensity or amplitude to the recorded sound waves. That is

to say, a tympanum adapted to regenerate by its own move ments when vibrated by the record, the original sounds, without the interposition of any horn or other confining transformer. The Examiner will recognize, we believe, that such a tympanum has long been sought for by those most skilled in the art, and this is evidenced by the patents cited, such as Shanks, Amet and Lumiere. Those patented devices were certainly failures, and, so far as we are aware, no one before the present applicant succeeded in producing such a tympanum. That the applicant has fully succeeded we can prove to the Examiner by demonstration, if he so desires. It is suggested that size is not a patentable limitation, and that in any case Lumiere disclosed a diaphragm more than nine inches in diameter. The fact is that the problem which the applicant endeavored to solve does not exist until the tympanum is made of very large diameter, that is, of diameter large enough to regenerate the original sounds. When work is attempted on such a large diameter it is found that the diaphragm vibrates at different rates and different intensities in different parts, so that it is divided into nodes of great activity, alternating with portions of little or no activity. Lumiere encountered this difficulty and attempted to solve the problem by the structure disclosed in his patent No. 986,177. We believe it can easily be proved that that attempt was a failure. The Lumiere patent belongs to the Victor Talking Machine Company, but that Company has never put upon the market any machines embodying the invention. However that may be, the applicants claims are carefully distinguished from Lumiere, which is not cited directly as a reference against them. In our opinion the suggestion that there is no invention

in the form of regenerating tympanum devised by the applicant, is entirely refuted by the Lumiere patent. If the small reproducer diaphragms of conical shape were in themselves sufficient to show those skilled in the art that the difficulties encountered by Lumiere could be overcome by adopting the form of tympanum adopted by the applicant, then Lumiere would have adopted that form. The fact is that the applicant has succeeded where others, and those most skilled in the art, have failed, and under those circumstances deductions which might otherwise be drawn from the earlier different, but now suggestive, patented structures, are overcome by the historical fact. We do not believe that the Examiner is justified in rejecting the applicant's tympanum claims unless he can find in the prior art a structure which in itself corresponds to those claims.

With respect to old claims 29, 40 and 41, now numbered 29, 30 and 31, we ask the Examiner to take into consideration the foregoing remarks. We believe that it will now be apparent to the Examiner that the selection of the particular dimensions is of the essense of the invention and attains novel results arising from the particular dimensions and such as could not be obtained by the devices shown in the references. If the Examiner desires to hear the results, we can arrange to make a demonstration for him here in New York, paying his traveling expenses for that purpose, or perhaps we can arrange to have one of the machines taken to the Patent Office.

An early and favorable reconsideration is respectfully solicited.

Lawrence Davis & Goldsborough
Attorneys for Applicant.

Div. 23 Room 379

Address only
The Commissioner of Patents,
Washington, D. C.,
and not any official by name.

2-259

Paper No. 6

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

LCE-Su WASHINGTON Feb. 23, 1915.

U. S. PATENT OFFICE
FEB 23 1915
MAILED

Pennie, Davis and Goldsborough,
35 Nassau Street,
New York, N. Y.

Please find below a communication from the EXAMINER in charge of the application of
Marcus C. Hopkins, for Sound Regenerating Machine, filed July 14, 1913, Serial No. 778,826.

Thomas Ewing
Commissioner of Patents.

In response to amendment of Feb. 6, 1915.

Page 7, line 7, "which are" should be canceled as duplicated in the following amendment.

It is doubtful to the examiner if a structure as disclosed by applicant will by itself produce sound waves corresponding in intensity to the recorded sound waves, as such requires that the entire energy represented by the recorded waves be transmitted without loss of energy to the diaphragm and that the diaphragm offer substantially no resistance to the movement so transmitted. If applicant insists on claims embodying such a limitation, he should satisfy this office by competent affidavits or by demonstration that such is true.

Claim 1 is rejected on Lumiere, of record, in view of the conical diaphragms of record. As such conical diaphragms are designed to be transversely rigid and operate in producing sound analogously to a piston, there would seem to be no apparent limit within a moderate range on the diameter which could be employed. Therefore, to increase the diameter of any such diaphragm, as in the references cited to perform an old function where there is no apparent limit to the diameter that may be employed, is not seen to be a display of invention. In re Pein, 201 O. G., 570.

Claim 2 is rejected on the above references and reasons. No

invention is seen, further, in enclosing Lumiere, or a similar structure, in a cabinet, especially in view of Miller, of record, Fig. 6, or such structures as in

Eckhardt, 903,364, Nov. 10, 1908, (181-3), or
Zappert, English, 17,827, July 31, 1909, (181-3), 1 sheet.

Claim 3 is rejected on the references and for the reasons of record. It is not seen that applicant's partition effects any different function from the partition in any cabinet that separates the record and needle compartment from the sound emitting compartment, as in

English, 947,227, Jan. 25, 1910, (181-3),

or from the partitions in Shields or Welton, of record. Therefore, to mount any of the long arm transmission devices of record in a cabinet with such a separating wall is thought but a matter of wise selection and adaptation, and not of invention.

Claim 4 is rejected on the references and for the reasons of record. In Johnson, 12 is a tympanum and 4 a transmitting arm. There would seem to be no invention in mounting Johnson in a cabinet, as in the German structure cited. So, also, e in Welton is a tympanum.

Claim 5 is rejected on the references and for the reasons of record. In Persichetti, a, f, is clearly a partition, and if his transmitting arm h were provided with a diaphragm at the mouth, as in Szek, or with a diaphragm, as in Johnson or Welton, the structure would meet the terms of this claim.

Claims 6 and 7 are rejected on the references and reasons of record and above given. If the mouth of h were flared, as in Szek, it would underlie e. See Fig. 2. The claims fail to bring out applicant's invention, being so broad and indefinite as to be met in widely different structures not involving invention.

Claim 8 is rejected on Johnson, for the reasons of record.

Claims 9 and 10 are allowed.

Claims 11, 13, 14, 15 and 16 are rejected on the grounds of

rejection of claim 1. The interposition of the cap of non-vibratile material in Lumiere, or any other old type of diaphragm substituted in Lumiere, is not seen to involve invention, in view of the common use of such in the art, for the same purpose as it is employed by applicant.

Claim 12 is rejected on the grounds of rejection of claim 1.

Claims 17 to 28 inclusive are allowed.

Claims 29, 30 and 31 are rejected on Lumiere, in view of the conical diaphragms of record, for the reasons above given.

Claims 32 to 35 inclusive are allowed.

Claim 7, line 3, "support" should be -holder-.

L.H.S.

H. W. Grove

Div. 23 - Room 379

#7

FEB 23 1916 U.S. PATENT OFFICE

UNITED STATES PATENT OFFICE

Application of MARCUS C. HOPKINS,
Serial No. 778,826,
Filed July 14, 1913,
SOUND REGENERATING MACHINE.

New York, February 22, 1916.

The Honorable Commissioner of Patents,
Washington, D.C.

S i r :

In response to Office Action of February 23, 1915, please amend as follows:

In the specification, page 7 line 16, change "substantially" to -at least-, and in line 19 change "substantially" to -at least-.

Page 8, line 20, strike out "that" at the beginning of the line.

Page 7, line 7, cancel "which are".

In the second line of claim 1 and the second line of claim 2, after the word "same" insert -without an amplifying horn or chamber- and make the same insertion in the second line of claim 11, claim 12, claim 13, claim 14, claim 15 and claim 16.

In claim 7, change "support" to -holder- in line 3.

R E M A R K S

In the last Office Action the Examiner expressed doubt whether the structure disclosed by applicant will itself produce sound waves corresponding in intensity

to the recorded sound waves "as such requires that the entire energy represented by the recorded waves be transmitted without loss of energy to the diaphragm and that the diaphragm offers substantial non-resistance to the movement to be transmitted" and called for affidavits or a demonstration. A demonstration of the machine was made to the Principal Examiner and his assistant last week, and we believe they were satisfied that the machine would produce, without an amplifying horn or chamber, sound waves substantially corresponding in intensity to the original recorded sound waves. Of course, the Assistant Examiner who wrote the last Office Action was mistaken in supposing that there is any necessary relation between the energy represented by the recorded waves and the energy delivered to the air by the diaphragm. Only a minute part of the energy of the recorded waves is gathered in by the recording trumpet and made use of to actuate the recording device. The energy put upon the air by the vibrating diaphragm is not at all the same energy that existed in the recorded waves, but is the energy of the motor which drives the record tablet in the reproducing machine.

We have amended claims 1 and 2 and claims 11 to 16, inclusive, to emphasize the fact that the machine has no horn or amplifying chamber. We do not believe that the Examiner will suggest that this is a negative limitation, and its purpose is consistent with the purpose which we have continually followed, that is, to distinguish the present machine from the ordinary machine in which the regenerator comprises a reproducer and a trumpet. In the opening part of the specification, we tried to make it clear that in ordinary machines, the reproducer, or sound

box, is incapable of generating sound waves of such a character as will persist in the air to any substantial extent. The character of the sound made by an ordinary phonograph sound box disconnected from the amplifying horn or chamber, is well known to the Examiner, and is, of course, easily distinguished in his mind from the sound produced by the sound box acting together with the amplifying horn or chamber. It has been demonstrated to the Examiner that the applicant's machine, without any amplifying horn or chamber, will produce a volume of sound which corresponds to the sound produced by the conjoint action of the sound box and amplifying chamber in an ordinary phonograph. In other words, the applicant's machine does, with its large diaphragm, what the old machines do with the combined diaphragm and amplifying horn or chamber, and in so doing the applicant's machine overcomes the limitations which necessarily reside in the use of a horn or chamber. This accomplishment is a perfectly definite thing which anyone can understand, which has often been tried before, and which is done by the applicant for the first time. We have done everything we possibly could do to define this distinction in the claims, and it seems to us that they do define it. The additional words inserted in the claims have not been inserted with the intent or purpose of changing their scope, nor is it intended that they shall in any way result in prolonging the prosecution of the case. They are merely an earnest of our purpose to distinguish definitely from the old machines in which an amplifying horn or chamber is used.

We hardly know what we can say in regard to that paragraph of the Examiner's letter which suggests that the applicant's accomplishment does not involve invention.

As we understand it, the argument is that Lumiere proposed to use a large diaphragm, but not a conical diaphragm; that small conical diaphragms are old in sound boxes, and that consequently there is no invention in using a large conical diapgragm. It seems to us that this proposition need only be stated to refute itself. The fact is that, although small conical diaphragms were old in sound boxes, Lumiere, who is one of the most skilled men in the art, not only did not know that a large conical diaphragm would accomplish his purpose, but was unable to accomplish that purpose at all. The Lumiere patent is owned by the Victor Talking Machine Company and it is well known to those skilled in the art that the suggestions of Lumiere were abortive and never resulted in an operative machine. The applicant's claims clearly differentiate from the Lumiere patent and that is all that is necessary. On the question of invention the Lumiere patent is pertinent to the present discussion only because it shows that prior to the applicant, the art did not know how to accomplish the applicant's result

This ground of rejection was applied by the Assistant Examiner to claims 1, 2, 11 to 16 inclusive and 29, 30 and 31, and we do not believe that the present Examiner will insist upon it with respect to any one of those claims.

With respect to claim 2, the suggestion is that there is no invention in enclosing Lumiere by a cabinet of the character specified in claim 2, in view of Miller, Eckhardt or Zappert. In the first place, claim 2 distinguishes from Lumiere so enclosed, and in the second place the other references do not show a phonograph in which the sound producing means could be enclosed in an open-work

cabinet affording substantial free access of the surrounding air thereto. These other references show horn machines, the very essence of which is that they should be open only on one side. Claim 2 defines an arrangement in which a direct reproducer is surrounded by an open-work cabinet so that the sound may be given off in every direction. There is nothing of the sort in the prior art.

With respect to claims 3 to 8, inclusive, the grounds of rejection are not well understood. Many patents have been cited against these claims and the Examiner has applied them in different ways in successive actions. It will, perhaps, be best to discuss each of the claims separately, referring to all of the references cited against them.

Claim 3, which was originally claim 5, was, in the first Office Action, rejected on Shanks, two Emet patents, Repp or Lumiere, mounted in any conventional cabinet as Skiff, "no invention being found in separating the record and diaphragm spaces by a partition", especially in view of Shields or Welton. As we understand it, the Shanks, Emet, Repp and Lumiere patents were cited to show devices in which the sound was reproduced without the use of an amplifier, by a sounding device connected to the needle holder by a transmission arm. It is not suggested that any one of these patents disclosed the combination of claim 3, wherein the record table is located in one compartment, and the sounding device in another, the transmission arm extending through the partition. In Skiff, the record table and the regenerator, comprising a sound box and an amplifying horn, are enclosed in a single

compartment, which is precisely what the applicant does not do. His idea is to have the record table in one compartment which may easily be opened to remove and replace the record, to have the sounding device in another compartment which is permanently closed, and to so arrange the transmitting arm that it can swing over the record and yet extend through the partition from the record table to the sounding device. In Shields the record holder and sound box are enclosed in the same compartment. There is no transmission arm proper, unless it be considered that the stylus 14 is a transmission arm, in which case it results that the record holder, the transmission arm and the sound box, are all in the same casing. There is no amplifier, because the phonograph illustrated is one of that type which was provided with a branched tube, the terminals of which were to be placed in the ears of the listener. In Welton the record table, transmission arm and sound box are in one compartment, through the wall of which the tone arm extends, an amplifying horn being attached to the tone arm outside of the casing. There is here no cabinet with two compartments, and we are unable to imagine in what respect the Examiner supposed that it has any bearing on claim 3.

In the second Office Action this claim was rejected on the references of record without any application of those references. In the last Office Action the claim was rejected on the references of record, together with the patent to English No. 947,227, which shows the ordinary Victrola type of machine with encased horn. It is true that in this machine, as in all machines of the Victrola

type, there are two compartments, one containing the record disk, the transmission arm and the sound box, together with the tone arm, and the other containing the amplifying chamber. It seems to us that claim 3 definitely distinguishes from such an arrangement, in that it specifies a transmission arm extending from one compartment to another with a tympanum located in one compartment and connected with the transmission arm. It would be a great mistake for the Examiner to assume that it was an easy thing to devise and construct a transmission arm capable of carrying the vibrations from the record groove to the outer edge of the record and through a partition to the tympanum. Thst was a very difficult thing to do, and in our judgment warrants the allowance of claim 3.

Claim 4 was originally claim 6, and was allowed in the first Office Action. In the second Office Action it was rejected on Johnson No. 1,015,321, together with Shields or Welton or the German patent No. 220,412. The Johnson patent shows merely a usual type of tone arm and the mechanism of the phonograph, excepting the motor, is entirely unenclosed The Shield and Welton patents have already been considered. The German patent is practically the same as Welton, excepting that the record table is covered by movable cover d. We do not understand how this is to be applied to the claim. In the last Office Action the Examiner says, referring to the Johnson patent, that "12 is a tynpanum and 4 a transmitting arm." That is certainly putting an extraordinary construction upon the language of claim 4, but let us apply that interpretation. If 4 is the transmission arm, then what is the partition upon which it is supported and through which it extends, and how can the tympanum 4 swing?

The Examiner apparently recognized that the Johnson reference is lacking in the cabinet structure claimed, and says that there would be no invention in mounting Johnson in the cabinet of the German patent. We do not understand how this mounting is to be made so that the claim will read upon it, but even if that can be done, it would be to reject the claim on references which lack the very thing claimed. The Examiner also suggests that in Welton e is the tympanum, but in this case he is no better off than in the Johnson patent. There is no partition upon which the transmission arm is mounted and through which it extends.

Claim 5, which was originally claim 7, was allowed in the first Office Action. In the second Office Action it was rejected on the combination of the French patent No. 397,609 and the British patent No. 8011 of 1906. In the French patent the tympanum is the ordinary sound box diaphragm and there is a horn which extends downwardly through a bracket arm f which cannot by any stretch of the imagination be considered a partition. Even if it were a partition, the claim would not be met. It is not pretended that the British patent meets the claim, and by combining the two the Examiner has added the very thing which characterizes the claim. Furthermore, the combination suggested by the Examiner would still not have any transmission arm extending through a partition.

Claim 6 originally claim 8, was allowed in the first Action and rejected in the second on the same references as claim 5, originally claim 7, and the same remarks apply to this claim. We may point out that it is one thing to bend a horn or tone arm, and another thing

to produce a transmission arm which will change the direction of the vibrations, as is necessary in claims 5 and 6. Really, the only difference between the action on claim 5 and the action on claim 6, is that claim 6 includes the further limitation that the tympanum is beneath the support and since this is not found in either of the references, the Examiner proposes to modify them so as to include it. Why should he not, having already injected into the references the characteristic element of the claim, which they did not disclose? Claim 7, originally claim 9, is rejected on the same references, and nothing need be said about it. Claim 8, originally claim 11, was rejected in the first action on Shelbe No. 957,004, and has been amended. In the second Office Action, as claim 10, it was rejected on Johnson, and in the last Office Action this rejection was repeated. To sustain this rejection the Examiner says "4 and 7 are the two arms", whereas the fact is that 4 and 7 are one arm; but even considering them as two arms, the tympanum is not carried by the arm 7.

It seems to us that the real explanation of the somewhat extraordinary application of references just discussed is found in the last Office Action, where the Examiner says:

> The claims fail to bring out applicant's invention, being so broad and indefinite as to be met in wisely different structures not involving invention".

We have carefully considered this suggestion, and it seems to us that the claims are not open to that criticism. If they are, we would be glad to amend them, but after re-

If the Examiner thinks otherwise, we would be glad t know it and have him say specifically wherein the claims are indefinite.

Although we understand that the Assistant Examiner who will act upon the case in response to this amendment is not the Assistant Examiner who has heretofore acted upon the case, yet we would like, if possible, to get a final action at this time.

Respectfully submitted,

Pennie Davis & Goldsborough

Attorneys for Applicant.

Div. 23 Room 379 — 2-2 — Paper No. 8

Address only "The Commissioner of Patents Washington, D. C." and not any official by name.

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

F_E WASHINGTON March 4, 1916.

Pennie, Davis and Goldsborough,
35 Nassau Street,
New York, N. Y.

U. S. PATENT OFF. E.
MAR 4 1916
MAILED

Please find below a communication from the EXAMINER in charge of the application of

Marcus C. Hopkins, for Sound Regenerating Machine, filed July 14, 1913, Serial No. 778,826.

Thomas Ewing
Commissioner of Patents.

In response to amendment of Feb. 23, 1916.

Claims 1, 3, 11 to 16 and 29 to 31 are rejected as indefinite. The specification of the size according to results is believed to be too indefinite. The examiner understands that the base diameter and the altitude must have a definite relative proportion, and that the base diameter must be substantially nine inches in order that satisfactory results can be obtained. To merely specify this size by the result is believed to be too indefinite. The basis of reference which is stated to be the recorded sound waves is believed to be an indefinite reference base, and that such a range would be too great and variable to be readily determined. For instance, a limitation such as from eight to ten inches for the base diameter might be given. The statement in some of the claims that the diameter exceeds nine inches is not believed to be sufficiently definite. If it is immaterial what the size is within a considerable range, then it is a mere question of expediency, or selection of any size one desires for any loudness, and would not involve invention.

Claims 3 to 6 are rejected on the references and reasons of record. It is not believed to require invention to

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put a partition anywhere one desires. If there is any invention, it is in the adaptation of the partition to the particular device. In other words, the construction by which the partition can be used is what involves the invention, if any, and not merely the idea of using a partition, as the claims now state. Attention is called to the decision in Thatcher Heating Co. vs. Burtis et al., C. D. 1887, 320, (or 39 O. G., 587), in which the U. S. Supreme Court held that there was no invention in the combination involved, no matter how or by what means it was effected; that the invention was in the means employed in making the adaptation.

The case appears otherwise allowable, as now advised.

J.

H. D. Crowbrock, Exr.

DIV. 23

#9

Room 379.

MAR 28 1916 U.S. PATENT

UNITED STATES PATENT OFFICE.

------oOo------

Marcus C. Hopkins,
Filed July 14, 1913,
Serial No. 778,826.

SOUND REGENERATING MACHINES.

------oOo------

Hon. Commissioner of Patents,

Sir:--

In response to the Official action of March 4,1916, please amend as follows:--

Page 6, last line, after "gripped between" insert - and rigidly supported -.

Claims 1 and 2, line 3, after "panum" insert - of large area rigidly supported at its periphery and freely exposed to unconfined air -.

Claims 11 and 12, line 3, after "tympanum" insert - of large area -.

Claim 11, line 4, before "mounted" insert - rigidly -.

Claim 12, line 4, before "mounted" insert - having its outer edge rigidly -.

Claim 13, line 5, before "mounted" insert - rigidly -.

Claim 14, line 3, after "aperture" insert - exceeding nine inches in diameter -. Line 4, before "secured" insert - rigidly -.

Claim 15, line 3, after "tympanum" insert - of large area -. Line 4, before "secured" insert - rigidly -. Line 6, after "support," insert - the inner diameter of said rim exceeding nine inches, -.

Claim 16, line 5, before "secured" insert - rigid-

Claims 29, 30 and 31, line 1, after "tympanum" insert - rigidly supported at its periphery -.

The foregoing amendments are made as the result of an oral interview recently had with the Examiner, at which it was agreed that the said amendments would not only more clearly define the invention, but would also render the material distinctions between the same and the prior art, including a number of patents which show horns or amplifiers of paper or other similar material directly associated with the reproducer needle, clearly apparent. It is essential to the success of applicant's machine that the tympanum be of large area and that the base of the vibratile portion thereof exceed nine inches in diameter, and furthermore that the peripheral edge of the tympanum, exterior of the vibratile portion, be rigidly secured or tightly gripped between the rings of the supporting frame. These definitions of the essential characteristics of the invention have been included in the claims by the amendments aforesaid, and said claims are, therefore, believed to be allowable.

The Examiner's objection that applicant indicates only the lower limit of the diameter of the tympanum and does not include both limits, is believed to be without substantial foundation. Applicant has demonstrated that his invention is not wholly satisfactory when the conical tympanum is made with a basal diameter of less than nine inches. He has also found that tympanums of much larger diameter are eminently successful, but he is not prepared to even indicate any maximum limit in respect of such diameter, nor should a statement of such an upper limit be required. He has produced a highly successful device which is novel and useful, and as the prior art discloses no similar device either structurally or operatively

considered, it is submitted that he has properly defined his invention in the claims, when he has distinguished the device, as so defined in the claims, from the prior art.

For example, in claims 1 and 2, it is stated that the vibratile conical tympanum is of large area rigidly supported at its periphery and freely exposed to unconfined air, so that when the tympanum is vibrated, it imparts to the surrounding free air, sound waves corresponding in intensity to the recorded sound waves. At a recent demonstration before the Examiner and his assistants, at the offices of applicant's attorneys in this city, it was made clearly manifest that the machine embodying the present invention did reproduce sounds or sound waves substantially corresponding in intensity to the recorded sound waves. The demonstrating machine was without any amplifying devices whatever in the form of a horn or sound-box, and the Examiner will recall that the sounds reproduced were clear, resonant, self-sustained and of admirable quality and timbre, and of an intensity which obviously approximated that of the recorded sound waves. It is, therefore, believed that the expression "substantially corresponding in intensity with the recorded sound waves" is correct and perspicuous and can give rise to no uncertainty or ambiguity. Of course, the term substantially implies a certain latitude, which the facts in the case would appear to justify, as all of the reproductions of recorded sounds by applicant's machine clearly indicate to the ordinary ear that they necessarily approximate the recorded sounds not only in intensity, but in timbre and quality.

In the other claims, as amended, the characteristic feature of mounting or supporting the outer edge of the vibratile tympanum rigidly on a support is brought out, and in some of

amendments go to structure and differentiate such structure from the prior art, it is urged that the claims are no longer open to the objection of indefiniteness.

In respect of the prior art patents, not of record, but to which attention has been called, and which show horns or other amplifying devices made of paper or the like and directly associated with the needle or stylus, attention is called to the fact that these devices do not differ in character from the ordinary amplifying horn or sound-box, and are not per se vibratile tumpanae, but mere amplifiers or condensers of sound waves. Furthermore, none of these prior art devices show any equivalent of a tympanum having its outer edge rigidly mounted in a support. In short, the horn-like reproducers are nothing more than the ordinary horn or amplifying megaphone having the stylus directly attached to its wall, so that the stylus sets up a localized vibration, which is confined within the flaring body of the horn and amplified and reproduced as sound waves, not by any vibration of the horn as a whole, but merely by the condensation and amplification of the vibrations of the stylus and the portion of the material of the horn immediately adjacent the stylus connection.

It is respectfully submitted that as amended, the claims clearly define the essential novelty of applicant's invention and should be allowed.

Respectfully submitted,

MARCUS C. HOPKINS,

by Lemuel Davis & Goldsborough

Attorneys.

Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

When writing about this case, always address as above, and give the following information: Name of applicant, title of invention, and name of this office.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

478

F_E WASHINGTON Apr. 1, 1916.

Pennie, Davis and Goldsborough,
35 Nassau Street,
New York, N. Y.

U. S. PATENT OFFICE
APR 1 1916
MAILED

Please find below a communication from the **EXAMINER** *in charge of the application of*

Marcus C. Hopkins, for Sound Regenerating Machine, filed July 14, 1913, Serial No. 778,825.

Thomas Ewing
Commissioner of Patents.

c 6—9901

In response to amendment of March 28, 1916.

No reply was made to the rejection of claims 3 to 6, made in the last office action. It is thought that this was an oversight by applicant.

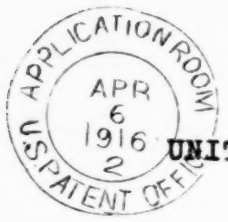
The amendment above mentioned must therefore be held to be an incomplete response to the last office action.

H. D. Crowbrek, Exr.

Room 379.

11

E



UNITED STATES PATENT OFFICE.

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M.C. Hopkins,
Filed July 14, 1913,
Serial No. 778,826..

: SOUND REGENERATING MACHINE.

--------:0:0:--------

Hon. Commissioner of Patents,

Sir:--

In the matter of the above entitled application, please cancel claims 3 to 6 inclusive and re-arrange the numerals of the other claims accordingly.

--

It was intended to cancel these claims by the last amendment, but through an inadvertence the matter was overlooked. The case is now believed to be in condition for allowance, and it is respectfully requested that it be passed to issue.

Respectfully submitted,

M.C. HOPKINS.

By Lewis & Davis & Goldsborough
Attorneys.

ADDRESS ONLY
THE COMMISSIONER OF PATENTS,
WASHINGTON, D. C.

2—181

Serial No.
778,826

BU.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON April. 11th. 1916.

Marcus C. Hopkins. Assor.

Sir: Your APPLICATION for a patent for an IMPROVEMENT in Sound Regenerating Machine.

filed July 14th. 1913. , has been examined and ALLOWED.

The final fee, TWENTY DOLLARS, must be paid not later than SIX MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent on this application will be withheld, unless renewed with an additional fee of $15, under the provisions of Section 4897, Revised Statutes.

The office delivers patents upon the day of their date, and on which their term begins to run. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will require about four weeks, and such work will not be undertaken until after payment of the necessary fee.

When you send the final fee you will also send, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If you desire to have the patent issue to ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of FIVE CENTS EACH. The money should accompany the order. Postage stamps will not be received.

Final fees will NOT be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Respectfully,

Thomas Ewing
Commissioner of Patents.

Pennie, Davis & Goldsborough.
35 Nassau St.
New York, N. Y.

6—1841

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED.

2038

23 #12

RECT'D MAR 22 1918 C.C.U.S.PAT.OFFICE

PETITION

Honorable Commissioner of Patents,

Washington, D. C.

Sir:

Your petitioner, MARCUS C. HOPKINS, a citizen of the United States, residing in the Borough of Manhattan, City, County and State of New York, whose post office address is No. 35 Nassau Street, New York City, N. Y., represents that on July 14, 1913, he filed an application for Letters Patent for an Improvement in SOUND REGENERATING MACHINES, Serial Number 778,826, which application was allowed April 11, 1916, but that he failed to make payment of the final fee within the time allowed by law. He now makes renewed application for Letters Patent for said invention, and prays that the original specification, oath and drawings, may be used as a part of this application.

SIGNED at New York City, New York, on this 21st day of March, 1918.

MARCUS C. HOPKINS,

By Pennie, Davis & Goldsborough
His Attorneys.

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2036

MAIL ROOM MAR 29 1918 U.S. PATENT OFFICE

#13

Div. 25 Room 379

DRW 23

UNITED STATES PATENT OFFICE

Application of MARCUS C. HOPKINS,

Renewal Serial Number 224,048,

Filed March 22, 1918,

SOUND REGENERATING MACHINE.

New York, March 28, 1918.

Honorable Commissioner of Patents,

Washington, D. C.

Sir:

Prior to the examination on the merits of the above case, please enter the following amendments as hereby directed:

Page 6, erase from "The", line 13, through "which", line 14, and substitute: -Two of the three arms of the said spider-; same page, line 24, correct the spelling of "underly" to underlie; change the last line as amended to read: - which peripheral portion or supporting rim 1 is tightly gripped and rigidly supported between the -.

Page 8, line 20, erase "that".

Page 14, between lines 5 and 6, insert the following:

-It will be noted that the distance between the point of the style g' and the axis of the lever Q is greater than the length of the arm U which projects from the center of the lever R and to which the rod V is connected. By reason of this fact, and of the fact that the levers Q and R, and the rod links S, S' form a parallelogram, the length of vibration of the tympanum is relatively much less than that of the style, and the tympanum thus offers little resistance to the movement of the style.

thereby greatly reducing the wear on the record. To compensate for this small movement of the tympanum, its large area enables it to move a large body of air, so as to obtain sound waves of large volume and great carrying power.

In line 2 of each of claims 5 and 6, insert a comma after "members".

Cancel claims 25, 26 and 27.

Add the following claims:

29. In a sound-regenerating machine, a vibratile conical tympanum of large area rigidly supported at its periphery and freely exposed to unconfined air, a sound-vibrated element, and vibration transmission means connecting said element and said tympanum and arranged to impart to the tympanum vibrations which are relatively much shorter than the vibrations imparted to the said element.

30. In a sound-regenerating machine, a vibratile conical tympanum rigidly supported at its periphery and freely exposed to unconfined air, a sound-vibrated element, and vibration transmission means connecting said element and said tympanum arranged to impart to the tympanum vibrations which are relatively much shorter than the vibrations imparted to the said element; the tympanum having an area sufficiently large to effect, without amplification, sound waves of large volume and carrying power.

31. In a sound-regenerating machine, a vibratile conical tympanum of large area, rigidly supported at its periphery and freely exposed to unconfined air, a sound-vibrated element, and tensioned transmission means connecting said element and said tympanum and arranged to impart to

the tympanum vibrations which are relatively much shorter than the vibrations imparted to the record end of the style.

Sigp.

REMARKS

It is desired to acknowledge the courtesy of the several extended interviews recently accorded in the matter of the above case. The added claims are based on claims standing allowed in the case and are assumed for that reason to be allowable. A short explanation has been incorporated in the specification as regards the relative length of the vibrations of the tympanum and the style or the sound vibrated element.

Claims 25, 26 and 27 have been canceled, as those claims will be incorporated, together with others, in a divisional application directed to the tympanum or diaphragm per se.

Respectfully submitted,

Pennie, Davis & Goldstough

Attorneys for Hopkins.

418

Div. 23 Room 217

Paper No. 14

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE

WASHINGTON April 5, 1918

WEB

PATENT OFFICE
APR 5 1918
MAILED

Rennie, Davis & Goldsborough,
35 Nassau St.,
New York

Please find below a communication from the EXAMINER in charge of the application of
Marcus C. Hopkins, Serial No. 224,048, filed March 22, 1918,
Sound Regenerating Machine.

James T. Newton
Commissioner of Patents

Responsive to amendment filed March 22, 1918.

Before this case can be passed to issue it will be necessary for applicant to certify over his own signature that his address as given in the renewal petition is correct, as it does not correspond with the address given in his original petition.

When properly certified the case may then be allowed.

W. D. Crowell,
Examiner

U.S. PATENT OFFICE APPLICATION DIV APR 18 1918

#15
Letter attached

IN THE UNITED STATES PATENT OFFICE

DIV 23

In re application of
Marcus C. Hopkins,
Sound Regenerating Machine,
Filed March 22, 1918,
Serial No. 224,048.

BEFORE THE EXAMINER
Room 217, Div. 23.

HON. COMMISSIONER OF PATENTS,
Washington, D. C.

Sir:

In response to the Official action of April 5, 1918, entry of the following amendments is hereby directed:

In line 2, of each of present claims 1, 2, 7, 8, 9, 10, 11, 12, erase "without an amplifying horn or chamber "

The matter to be erased is incorporated as an amendment in the communication filed February 23, 1916. Upon consideration, it appears that said matter is unnecessary to the claims from which it is erased.

Enter the attached signed statement as to applicant's post office address.

Allowance of the case is asked.

Respectfully submitted,

MARCUS C. HOPKINS,

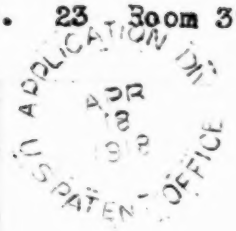
By Pennie, Davis & Goldsborough
Attorneys.

Washington, D. C.
April 18, 1918.

420

22
2038

Div. 23 Room 379



UNITED STATES PATENT OFFICE

Application of MARCUS C. HOPKINS,
Renewal Serial Number 224,048,
Filed March 22, 1918,
SOUND REGENERATING MACHINES.

New York, N.Y., April 6, 1918.

Honorable Commissioner of Patents,
Washington, D. C.

Sir:

I hereby certify that my address as given in the renewal petition in the above entitled application is correct; that I now reside in the Borough of Manhattan, City, County and State of New York, and that my post office address is No. 35 Nassau Street, New York City.

Respectfully,

Marcus C. Hopkins

12-3
2036

Room 217 Div. 23.

#9/16

APPLICATION FILED APR 20 1918 PATENT OFFICE

Dis. 11824
22

IN THE UNITED STATES PATENT OFFICE.

Application of MARCUS C. HOPKINS

Filed March 22, 1918

Serial No. 224,048

SOUND REGENERATING MACHINE

New York, N. Y., April 19, 1918

Honorable Commissioner of Patents

Washington, D. C.

S i r:

Claim 11, change line 6, as amended, to read, an annular rim adjacent said support, the outer diameter of said rim exceeding nine inches, and a conical por.

R E M A R K S.

Claim 11 has been amended to correct an inaccuracy which renders it inconsistent with, e.g., Claim 12. The circular aperture in the support exceeds nine inches in diameter.

Respectfully submitted,

Pennie, Davis & Goldsborough

Attorneys for Hopkins.

422

ADDRESS ONLY
THE COMMISSIONER OF PATENTS,
WASHINGTON, D. C.

AE 2—181 · **Serial No.** 778,826

DEPARTMENT OF THE INTERIOR 224,048

UNITED STATES PATENT OFFICE

WASHINGTON May 1, 1918.

Marcus C. Hopkins, Assor.,

Sir: Your APPLICATION for a patent for an IMPROVEMENT in Sound Regenerating Machine, filed Mar. 22, 1918, has been examined and ALLOWED.

The final fee, TWENTY DOLLARS, must be paid not later than SIX MONTHS from the date of this present notice of allowance. If the final fee be not paid within that period, the patent on this application will be withheld, unless renewed with an additional fee of $15, under the provisions of Section 4897, Revised Statutes.

The office delivers patents upon the day of their date, and on which their term begins to run. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will require about four weeks, and such work will not be undertaken until after payment of the necessary fee.

When you send the final fee you will also send, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, TITLE OF INVENTION, AND SERIAL NUMBER AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If you desire to have the patent issue to ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of FIVE CENTS EACH. The money should accompany the order. Postage stamps will not be received.

Final fees will NOT be received from other than the applicant, his assignee or attorney, or a party in interest as shown by the records of the Patent Office.

Respectfully,

J. T. Newton

Thomas Ewing

Commissioner of Patents.

Pennie, Davis & Goldsborough

35 Nassau Street,

New York, N. Y.

6—1918

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

UNCERTIFIED CHECKS WILL NOT BE ACCEPTED.

MAIL ROOM JUN 3 1913 U.S. PATENT OFFICE

Washington, D.C.,

June 3, 1918.

Hon. Commissioner of Patents,

Washington, D.C.

Sir:-

Final fees are being paid today in the following cases of Marcus C. Hopkins, 778,826, Renewal 224,048, Sound Regenerating Machine; 808,577, Renewal 224,049, Sound Regenerating Machine; and 229,014, Acoustic Device. It is requested that the case first identified be given the lowest patent number.

Very respectfully,

Prouty, Davis, Marvin & Edmonds

$20 REC'D JUN 3 1918 U.S. PAT. OFFICE

~~2036~~ ~~3-527.~~

MEMORANDUM

OF

FEE PAID AT UNITED STATES PATENT OFFICE.

(Be careful to give correct Serial No.)

Serial No. ~~Re. 224,048~~ 778,826 June 1, 1918.

INVENTOR:

MARCUS C. HOPKINS

PATENT TO BE ISSUED TO

LEKTOPHONE CORPORATION

NAME OF INVENTION, AS ALLOWED:

SOUND REGENERATING MACHINE

DATE OF PAYMENT:

June 3, 1918.

FEE:

TWENTY DOLLARS

DATE OF FILING:

March 22, 1918.

DATE OF CIRCULAR OF ALLOWANCE:

May 1, 1918.

The Commissioner of Patents will please apply the accompanying fee as indicated above.

Pennie, Davis & Edmonds

Attorneys

SEND PATENT TO

PENNIE, DAVIS, MARVIN & EDMONDS,

35 Nassau Street,

New York City.

6-1916

JOHN C. PENNIE
WILLIAM H. DAVIS
ARBA B. MARVIN
DEAN S. EDMONDS
F. E. BARROWS
W. B. MORTON
WALTER J. GILL, JR.
G. J. HERSELMAN
CLINTON W. SAGE
E. H. MERCHANT
A. S. McDANIEL
W. H. TAYLOR, JR.
V. T. HOUGHTON
H. T. FISHER
DAVID WEILD

PENNIE, DAVIS, MARVIN AND EDMONDS
COUNSELLORS AT LAW
35 NASSAU STREET

WASHINGTON OFFICES
910 WASHINGTON LOAN & TRUST BLDG.
WASHINGTON, D. C.
NEW YORK CABLE ADDRESS
PENANGOLD NEW YORK
WESTERN UNION CODE
TELEPHONE 1127 RECTOR

NEW YORK August 24, 1920.

B

2036

Honorable Commissioner of Patents,

Washington, D.C.

S[illegible] R :

In comparing our office copy of the file wrapper with the original deed of patent No. 1,271,527 issued on the second day of July, 1918 to Marcus C. Hopkins, for Sound Regenerating Machine, we note the following errors occurring in the printed copy:

Page 1, line 25, "magaphone" appears for - megaphone -;

Page 5, lines 75 and 95; page 6, line 25, "long" appears for - large -.

We are enclosing the original patent deed herewith and request that you kindly issue a certificate of correction covering these inaccuracies.

Very respectfully,

Pennie, Davis, Marvin & Edmonds

ENCLOSURE

Approved

SEP 16 1920

[illegible]
Commissioner of Patents

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

LETTER No.

DEPARTMENT OF THE INTERIOR
UNITED STATES PATENT OFFICE
WASHINGTON

7 September 1920.

In the matter of
Letters Patent No. 1,271,527,
Marcus C. Hopkins,
Sound-Regenerating Machines,
July 2,1920
Pennie,Davis,Marvin and Edmonds,attorneys.

REPORT OF THE ACTING CHIEF OF THE ISSUE AND GAZETTE DIVISION.

The attorneys return the Letters Patent with a request that a certificate of correction be issued correcting the following errors:

1. Page 1, line 25, "magaphone" should be megaphone
2. Page 5, lines 75 and 95, page 6, line 25 the word "long" should be large

The first error is chargeable to the printer. The second error is caused through the incorrect entry of a portion of amendment "D" paper 9, filed March 28,1916.

Respectfully,

John Hams

Acting Chief of Issue and Gazette Division

To The Commissioner of Patents. have been checked and are found

The errors referred to ~~appear~~ to have occurred in the manner alleged by the Chief of the Issue and Gazette Division.

Respectfully,

H. D. Emerson

Exr. Div. 23

October 6, 1920.

Messrs. Pennie,Davis,Marvin & Edmonds,
35 Nassau Street,
New York, N. Y.

Sirs:

Herewith please find Letters Patent No. 1,271,527, granted July 2, 1918,upon the application of Marcu C. Hopkins, returned to you with a certificate of correction endorsed thereon in accordance with your request.

Respectfully,

Wm.I.Wyman,
Chief Clerk.

MAIL ROOM NOV 12 1924 U.S. PATENT OFFICE

United States District Court

Eastern District of New York.

#17

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 (42 Stat. L. 392), you are advised that there was filed on the 10th day of November, 1924, in this court an action, suit, or proceeding No. 8-30-23, entitled:

Name Telephone Corporation, Plaintiff,

Address Jersey City, New Jersey

versus

Name Western Electric Company Inc., Defendant,

Address New York N.Y.

brought upon the following patents:

	PATENT NO.	DATE OF PATENT	PATENTEE
1	1271,527	July 2nd 1918	Telephone Company.
2			
3			
4			
5			

In the above-entitled case, on the ..... day of ....., 192 , the following patents have been included by ..... (insert amendment, answer, cross bill, or other pleading):

	PATENT NO.	DATE OF PATENT	PATENTEE
1			
2			
3			
4			
5			

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

In witness whereof I have affixed my hand this 11th day of November, 1924, at New York. N.Y.

Alexander Gilchrist Jr.
Clerk of said Court.

MAIL ROOM FEB 13 1925 U.S. PATENT OFFICE

United States District Court

Southern District of New York

#18

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 (~~41~~ 42 Stat. L. 392), you are advised that there was filed on the 13th day of February, 1925, in this court an action, suit, or proceeding No. E 31-171, entitled:

Name Telephone Corporation, Plaintiff,

Address Jersey City N.J.

versus

Name Vitalis Hummer Jr., Defendant,

Address N.Y. N.Y.

brought upon the following patents:

	PATENT NO.	DATE OF PATENT	PATENTEE
1.	1271527	July 2 1918	Marcus B Hopkins
2.			
3.			
4.			
5.			

In the above-entitled case, on the ..... day of ....., 192

the following patents have been included by ..... (insert amendment, answer, cross bill, or other pleading):

	PATENT NO.	DATE OF PATENT	PATENTEE
1.			
2.			
3.			
4.			
5.			

In the above-entitled case the following decision has been rendered or decree issued:

In witness whereof I have affixed my hand this 14th day of February, 1925, at New York N.Y.

Alexander Gilchrist Jr
Clerk of said Court

MAIL ROOM MAY 26 1925

United States District Court

Eastern District of New-York

#19

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 (42 Stat. L. ...), you are advised that there was filed on the 3rd day of March, 1925, in this court an action, suit, or proceeding No. 2075, entitled:

Name Lektophone Corp, Plaintiff,
Address Jersey City, N J

versus

Name Sylo Lighting Fixture Co, Defendant,
Address 166 Flatbush Ave., Brooklyn New York

brought upon the following patents:

	PATENT NO.	DATE OF PATENT	PATENTEE
1.	1271527	July 2, 1918	Plaintiff as Assignee
2.	1271529	" "	" " "
3.			
4.			
5.			

In the above-entitled case, on the ... day of ..., 192..., the following patents have been included by ... (insert amendment, answer, cross bill, or other pleading):

	PATENT NO.	DATE OF PATENT	PATENTEE
1.			
2.			
3.			
4.			
5.			

In the above-entitled case the following decision has been rendered or decree issued:

In witness whereof I have affixed my hand this 25th day of May, 1925, at Brooklyn New York

Percy J. Blake

Form 788

#20

MAIL ROOM NOV 3 1925 U.S. PATENT OFFICE

United States District Court

District of NEW JERSEY

HONORABLE COMMISSIONER OF PATENTS,
Washington, D. C.

SIR:

In compliance with the Act of February 18, 1922 (42 ~~Stat.~~ Stat. L. ....., you are advised that there was filed on the 4th day of September, 1925, in this court an action, suit, or proceeding No. E-1431, entitled:

Name Lektophone Corporation, Plaintiff,

Address Jersey City, N. J.

versus

Name De Forest Radio Company, Defendant,

Address 139 Franklin St., Jersey City, N. J.

brought upon the following patents:

	PATENT NO.	DATE OF PATENT	PATENTEE
1	1,271,527	July 14, 1913	Marcus C. Hopkins
2	1,271,529	July 14, 1913	Marcus C. Hopkins
3			
4			
5			

In the above-entitled case, on the ..... day of ....., 192 , the following patents have been included by .....(insert amendment, answer, cross bill, or other pleading):

	PATENT NO.	DATE OF PATENT	PATENTEE
1			
2			
3			
4			
5			

In the above-entitled case the following decision has been rendered or decree issued:

.....

.....

In witness whereof I have affixed my hand this 28th day of October, 1925, at Trenton, N. J.

George T. Cranmer
Clerk of said Court

R. S. Cherries, Deputy

M. C. HOPKINS.

SOUND REGENERATING MACHINE.

APPLICATION FILED JULY 14, 1913. RENEWED MAR. 22, 1918.

1,271,527.

Patented July 2, 1918.

5 SHEETS—SHEET 1.

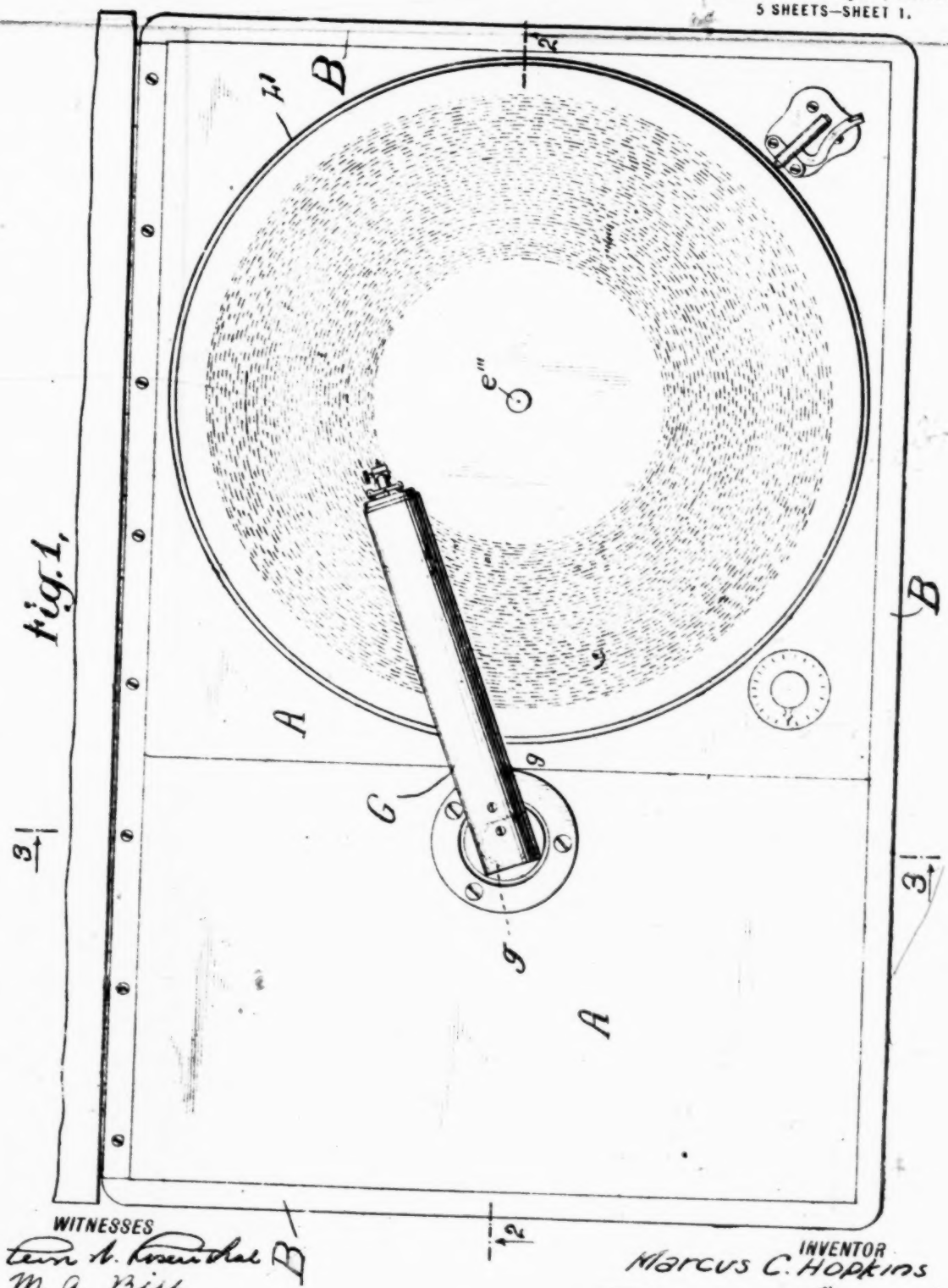


Fig. 1.

WITNESSES

Louis A. Rosenthal

M. A. Bill

INVENTOR

Marcus C. Hopkins

BY

Louis Davis Goldsmith

ATTORNEYS

M. C. HOPKINS.

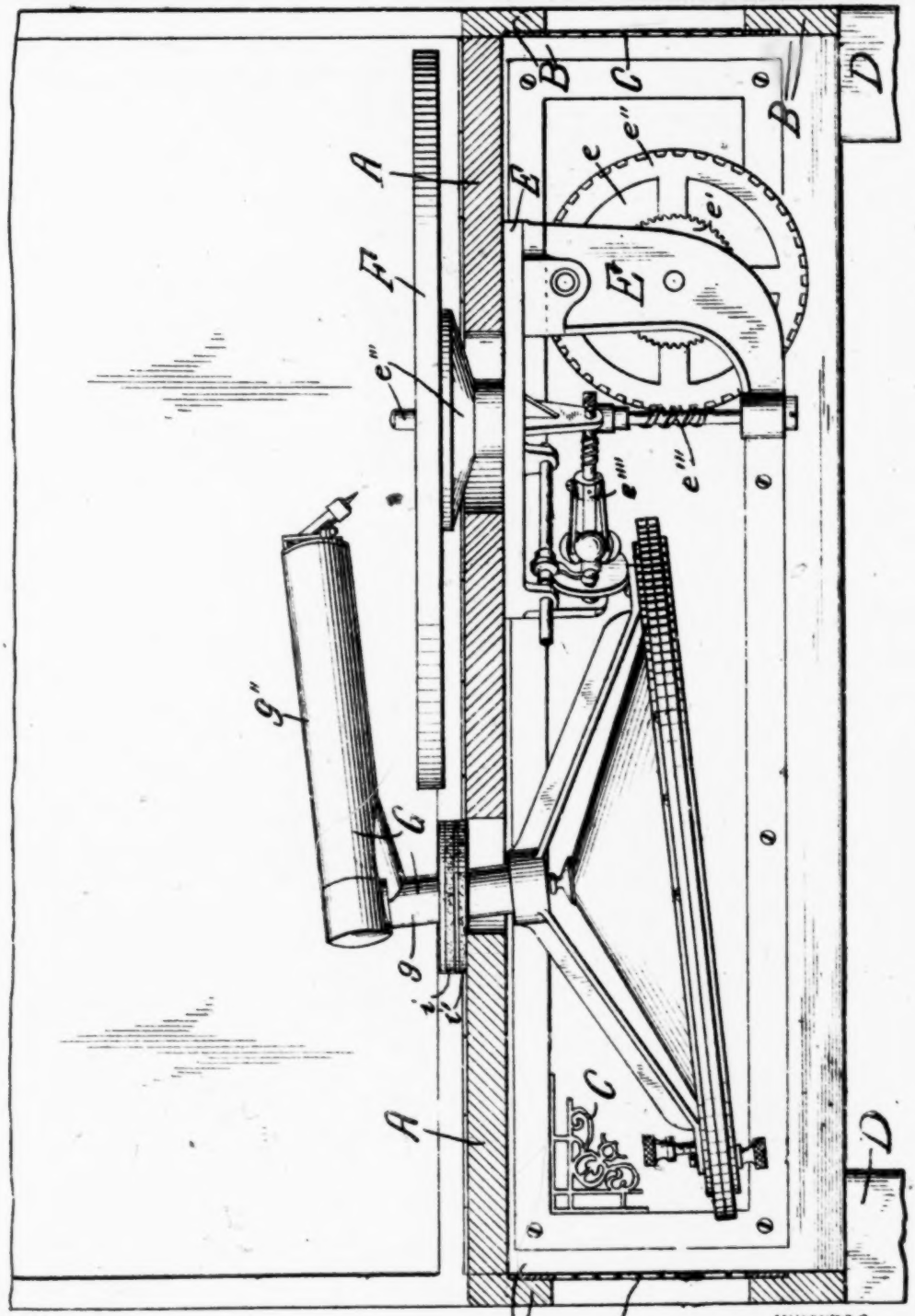
SOUND REGENERATING MACHINE.

APPLICATION FILED JULY 14, 1913. RENEWED MAR. 22, 1918.

1,271,527. Patented July 2, 1918.

5 SHEETS—SHEET 2.

Fig. 2.



WITNESSES

Leon A. Rosenthal

M. A. Bill

INVENTOR

Marcus C. Hopkins

BY

Munn & Parce & Glasebrook

ATTORNEYS

M. C. HOPKINS.

SOUND REGENERATING MACHINE.

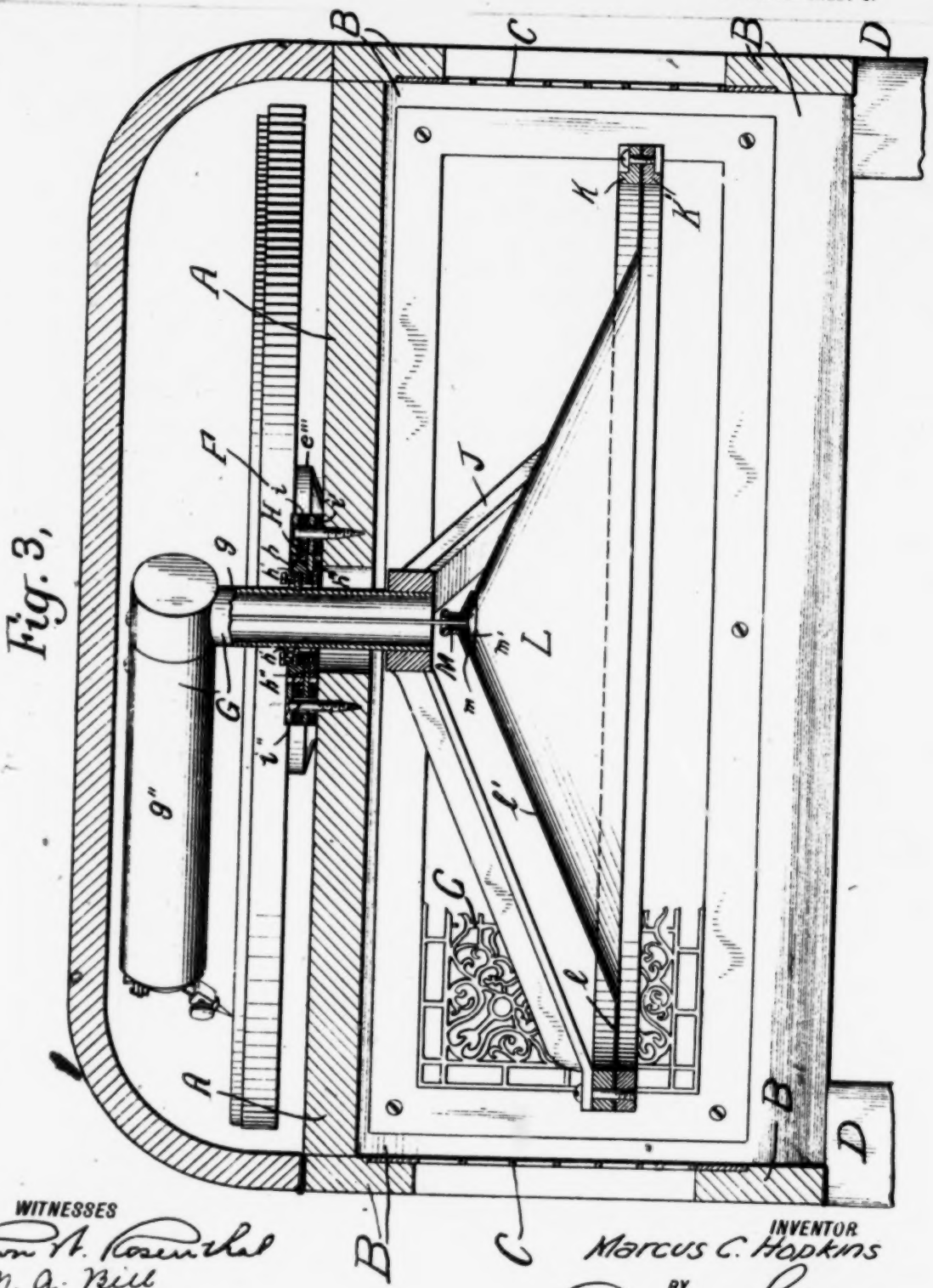
APPLICATION FILED JULY 14, 1913. RENEWED MAR. 22, 1918.

1,271,527.

Patented July 2, 1918.

5 SHEETS—SHEET 3.

Fig. 3.



WITNESSES

Lewis A. Rosenthal

M. A. Bill

INVENTOR

Marcus C. Hopkins

BY

Pennie Davis & Edmonds

ATTORNEYS

M. C. HOPKINS.

SOUND REGENERATING MACHINE.

APPLICATION FILED JULY 14, 1913. RENEWED MAR. 22, 1918.

1,271,527.

Patented July 2, 1918.

5 SHEETS—SHEET 4.

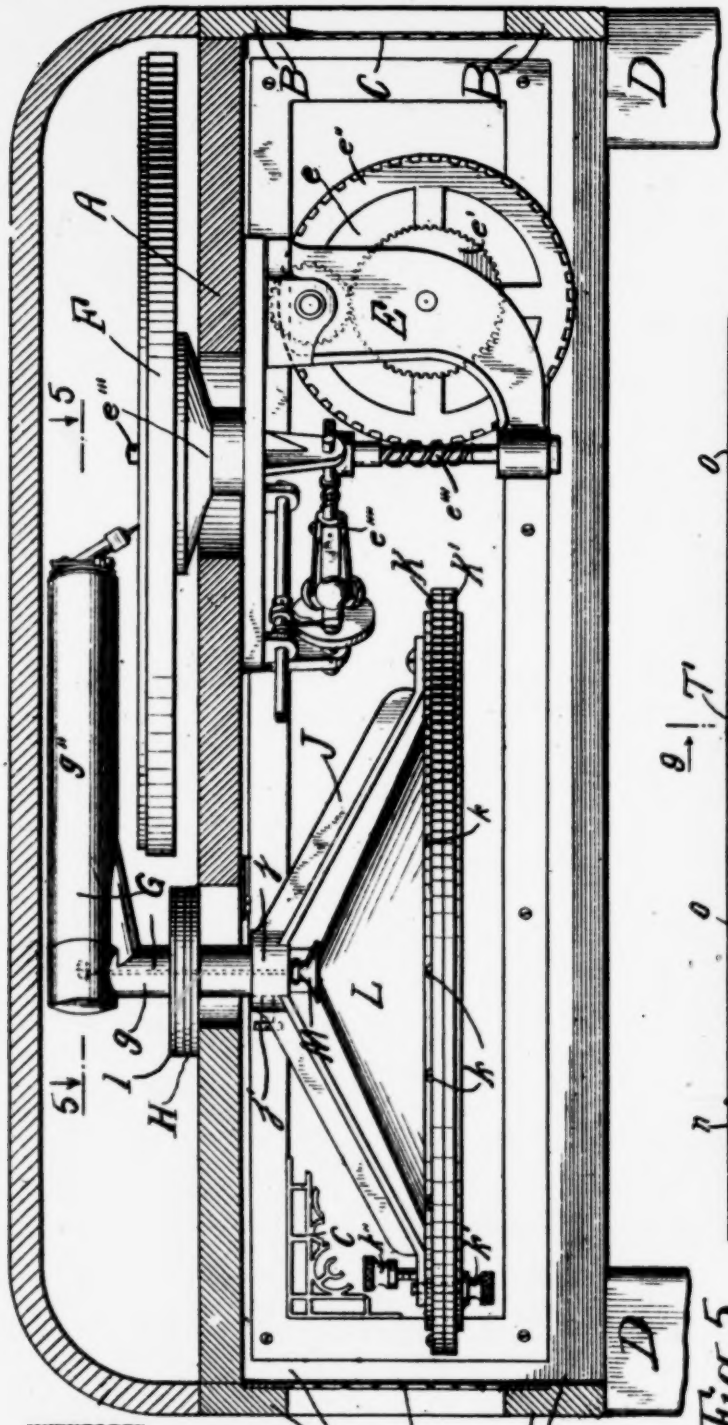


Fig. 4.

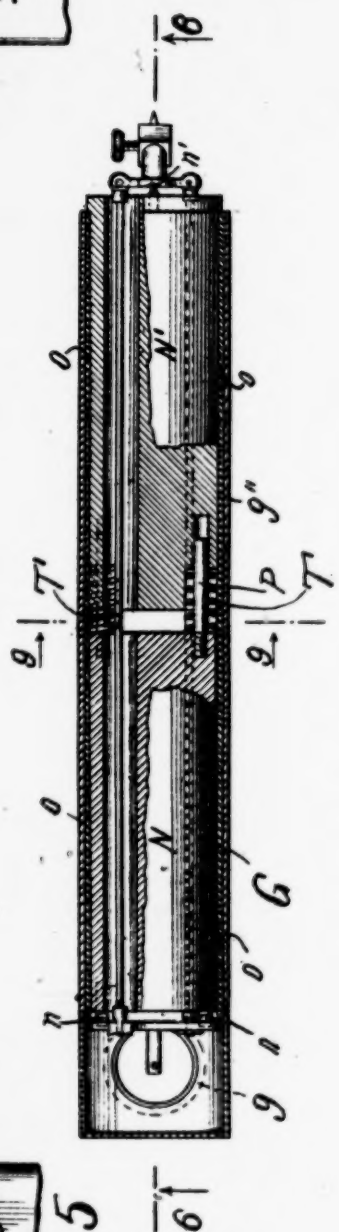


Fig. 5.

WITNESSES

Leon A. Rosenthal

M. A. Rice

INVENTOR.

Marcus C. Hopkins

BY

Pennie Davis & Goldstone

ATTORNEYS

M. C. HOPKINS.

SOUND REGENERATING MACHINE.

APPLICATION FILED JULY 14, 1913. RENEWED MAR. 22, 1918.

1,271,527.

Patented July 2, 1918.

5 SHEETS—SHEET 5.

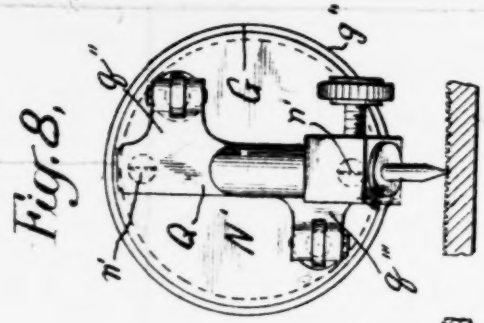


Fig. 8.

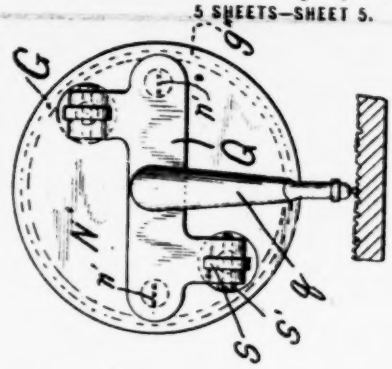


Fig. 10.

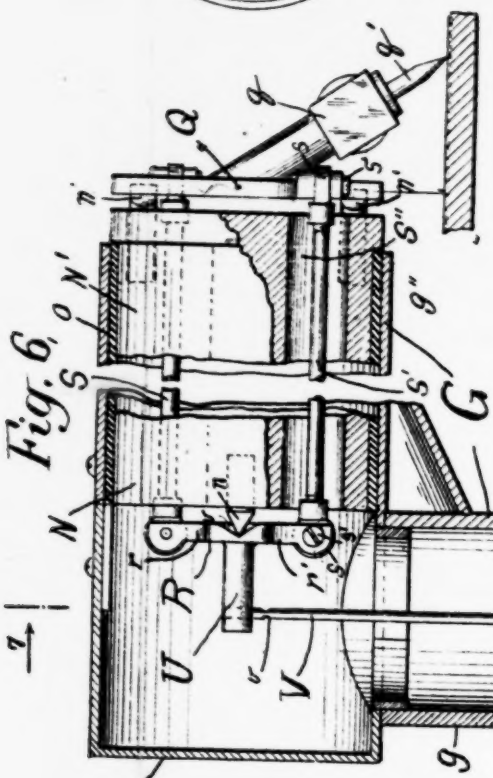


Fig. 6.

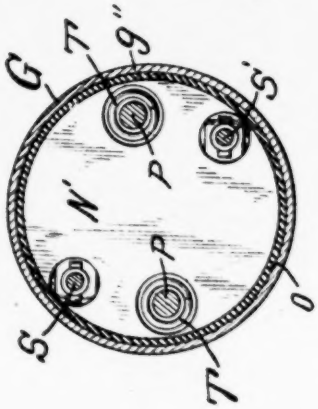


Fig. 9.

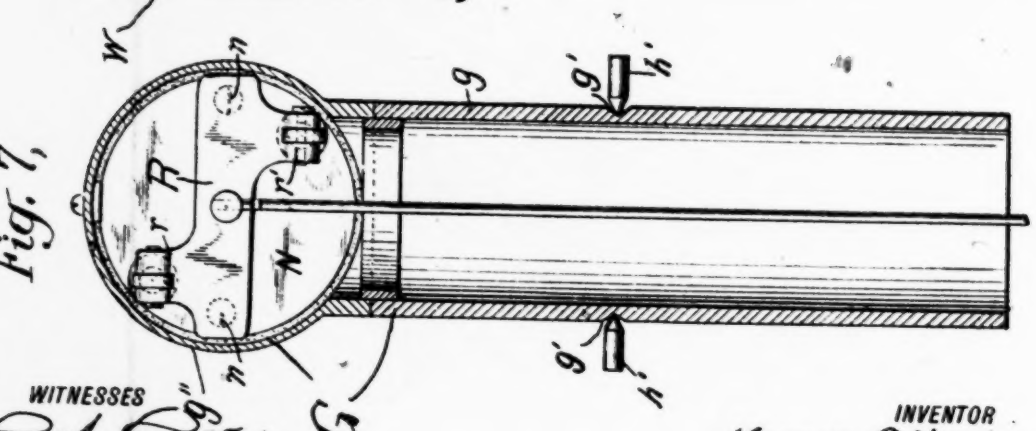


Fig. 7.

WITNESSES

Leon A. Lamontagne

M. A. Bill

INVENTOR

Marcus C. Hopkins

BY

Louis Dare & Glashorny

ATTORNEYS

UNITED STATES PATENT OFFICE.

MARCUS C. HOPKINS, OF JERSEY CITY, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO LEKTOPHONE CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

SOUND-REGENERATING MACHINE.

1,271,527. Specification of Letters Patent. Patented July 2, 1918.

Application filed July 14, 1913, Serial No. 778,828. Renewed March 22, 1918. Serial No. 224,048.

To all whom it may concern:

Be it known that I, MARCUS C. HOPKINS, a citizen of the United States, residing at No. 2859 Boulevard, Jersey City, county of Hudson, and State of New Jersey, have invented certain new and useful Improvements in Sound-Regenerating Machines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to instruments which reproduce sounds, such as the talking machine and the phonograph, and is particularly directed to the attainment of a direct propagation in free air from a record of self-sustaining sound waves substantially corresponding to the original recorded sounds in intensity or amplitude as well as in pitch and timbre, as distinguished from an initial generation of violent air disturbances in a confined space, and a subsequent transformation of such disturbances into self-sustaining sound waves by means of the magaphone or trumpet, commonly employed with most existing machines.

The device employed to propagate such regenerated sound waves in air from a record I herein term a "regenerator," and, this device in the phonograph and talking machine comprises the "reproducer" together with the trumpet. The "reproducer" alone is incapable of generating such sound waves in air, and the violent air disturbances which are produced by its diaphragm, and which issue through its mouth piece, are almost immediately dissipated in heat or in waves, which are not heard at any considerable distance if the horn be removed.

In the case of the "reproducer," all of the energy received from the record issues from its mouth as relatively violent disturbances, which are impressed upon a very small amount of free air, quite incapable of conducting such disturbances without transformation losses, and therefore the trumpet is resorted to to resist transformation into heat and to control the lateral form of the wave during a progressive spreading action, which is accompanied by a lessening of the violence of the disturbances, until a wave front of great area is attained having a movement appropriate to the sound conductivity of air. In this way it has been found practicable to transform a satisfactory part of the energy obtained from a moving record, into self-sustaining sound waves in air, but in every instance this method has been accompanied by distortions of the true recorded sounds in the reproducer, and more particularly in the trumpet, giving rise to those characteristic sounds, known as phonograph and horn sounds. These distortions of the true sounds are in a measure impressed upon the record in its making, but are more noticeable in the reproduction where a suppression of character and overtones, the loss of "timbre" in instruments and the voice, and the accentuation of notes of certain pitch, so change the recorded number that a faithful reproduction is not obtained.

It is an object of the present invention to regenerate the recorded sounds directly from the record, without the interposition of a confined body of air and without the employment of a restrictive transformer, such as a horn.

The "sound regenerator," in the case of the present invention, comprises a tympanum of relatively great area freely exposed to unconfined air, in which the sounds are to be propagated, and a mechanical transmission which faithfully transmits the vibrations produced by the record, to the tympanum, in such manner that the tympanum excites directly in the free air surrounding it sound waves of an intensity or amplitude substantially corresponding to the original recorded sound waves. In other words, the original sounds are directly regenerated by the vibrating tympanum without the interposition of a restrictive or sound modifying transformer.

The invention consists in providing a tympanum of novel construction, which is capable of responding to the high frequency vibrations employed in the reproduction of sounds, and of imparting these vibrations to a large body of air; in providing a suitable mounting for this tympanum to permit it to exercise its function; and in providing a vibration transmission for receiving the vibratory movement from the record and transmitting this movement to the tympanum, without change of character and ap-

preciable loss of energy. The invention also comprehends certain combinations of parts and details of construction and location hereinafter particularly described and specifically pointed out in the appended claims.

I have illustrated in the accompanying drawings a sound reproducing machine embodying the several novel features of the invention as they may be employed in regenerating sounds from records made with either laterally or vertically sinuous grooves.

In the drawings,

Figure 1 is a plan view of the machine with the cover raised.

Fig. 2 is a vertical section on line 2—2 of Fig. 1, with cover and transmission arm raised.

Fig. 3 is a vertical section on line 3—3 of Fig. 1 with cover closed.

Fig. 4 is a vertical section on line 2—2 of Fig. 1 with cover closed and transmission arm in playing position.

Fig. 5 is a longitudinal section through the transmission arm on line 5—5 of Fig. 4.

Fig. 6 is a vertical longitudinal section through the transmission arm on line 6—6 of Fig. 5.

Fig. 7 is a vertical section on line 7—7 of Fig. 6.

Fig. 8 is an end view of the transmission arm.

Fig. 9 is a cross-section on line 9—9 of Fig. 5, and

Fig. 10 is a view similar to Fig. 8 of a modified arrangement for vertically sinuous records.

Referring to the drawings, the illustrated machine is mounted within a cabinet having a deck A upon which the motor and sound regenerator are supported. Side walls B downwardly extending from the edges of the deck A are preferably apertured on all sides and provided with open work grilles C which afford substantially uninterrupted air paths for the sound waves from the interior of the cabinet in all directions laterally to the surrounding atmosphere. In the machine shown the cabinet is bottomless and provided with legs D at its four corners.

The motor may be of any suitable type, that shown having a frame E, spring drums e, winding gear e', spiral drive gear e'', high pitch spiral table shaft e''' and governor e''''. The frame E of the motor is secured against the under side of the deck A depending therefrom and the table shaft projects upwardly through the deck A and carries the circular record table F above the deck. The motor frame E is preferably insulated from the deck A by rubber washers not shown.

The sound regenerator has a right-angled tubular support G, the vertical arm g of which has diametrically opposite conical depressions g' which are engaged by pointed screws h' which project inwardly from and are threaded through a ring h of larger internal diameter than the external diameter of the vertical arm g of the right-angled support G. The pointed screws h' engage the depressions g' forming a horizontal axis perpendicular to the horizontal arm g'' of the right-angled support G about which axis the arm g'' can swing in a vertical plane, the vertical arm g the while being inclined within the ring h. The ring h comprises the ring h proper and an annular retaining plate h'' screwed upon the lower face of the ring h, an annular groove at the junction of the ring h and plate h'' receiving the inner edge of a holding plate H in such manner that the ring h and the right-angled support G may be turned about a vertical axis in the holding plate H.

The holding plate H is clamped between two rubber or felt rings i, i', the lower ring i' resting upon the deck A. A ring I is placed upon the top of the upper ring i and screws i'' have their heads seated in the ring I and are screwed down into the deck A. The ring H and the rubber or felt rings i and i' have large holes through which the screws i'' pass, so that these screws do not come into contact with the ring H and the right-angled support G is therefore entirely insulated from the deck A by the rubber or felt rings. The vertical arm g of the right-angled support G extends downwardly through an aperture in the deck A at a point near the periphery of the record table F. A conical spider J shown as having three arms has its hub j fitted to the lower extremity of the vertical arm g of the right-angled support G, and is secured thereon by a set screw j'. To the ends of the arms of the spider J is secured by screws an annulus consisting of two ponderous rings K, K' of metal, these two rings being clamped together by screws k spaced at short intervals. Two of the three arms of the said spider are screwed tightly to the rings K, K' and the third is not tightly secured to said rings but by adjustable screws k' k'' arranged in such manner that the rings K, K' can be secured at varying distances from the foot of this third leg, there being sufficient spring in the spider legs to permit of an adjustment at this point of one-quarter of an inch or so, if desired. It will be seen that owing to the proximity of the mounting of the vertical arm g of the right-angled support G to the edge of the record table F, the spider J and the rings K, K' will underlie the record table and permit of a very compact arrangement of the working parts within the cabinet.

A tympanum L of light vibratile material has an annular plane peripheral portion l, the outer edge of which peripheral

portion or supporting rim *l* is tightly gripped and rigidly supported between the ponderous rings K, K′, and a central conical portion *l′* rising from the inner edge of the annular plane peripheral portion. If satisfactory regeneration of sounds from a record is to be had, the whole diameter of the tympanum, that is, the diameter of the aperture in the rings K, K′, should exceed nine inches in order that the conditions shall be fulfilled which are required to regenerate the sound waves in the manner above described. The base of the central conical portion *l′* of the tympanum should exceed in area one-half the effective area of the entire tympanum, that is, the area of the aperture in the rings K, K′; or in other words, the diameter of the base of said conical portion should be at least eight-tenths of the diameter of the circular aperture in the supporting rings K, K′. The altitude of the conical portion *l′* of the tympanum should be at least one-quarter of the diameter of its base. It is, of course, possible to make some variation from the approximate sizes given without materially altering the result, but if the tympanum is made as shown in the drawings, any great variation from these proportions will be found to affect the character of the reproduction. It is of vital importance that the tympanum be made of crisp, strong material, having considerable rigidity within itself, and it is also of vital importance that the tympanum as a whole be extremely light and have as little inertia as possible without a weakening effect. The tympanum is shown of conical form with a smooth surface, and this has been found to be very satisfactory. The conical shape is given the tympanum so that shocks or vibrations impressed upon the apex of the cone in a direction toward its base will move the whole cone bodily, the strains being imparted edgewise of the material and no wave motions being set up in the thin material of the cone. The curvature of the walls of the cone preclude the setting up of waves in the material and the intended object, a simultaneous movement of the whole conical portion of the tympanum, is attained. While I prefer to construct the tympanum in the form described and shown with a smooth surface, especially in view of the ease of construction, yet it is possible to form radial corrugations in the conical portion *l′* and radial or concentric corrugations in the plane peripheral portion *l* and produce a light, stiff and very satisfactory article for the purpose. It is possible that when the tympanum is provided with corrugations as just suggested, some variation from the proportions above given may be found possible, and perhaps advisable, but such variations from the proportions given will not be great. The tympanum should preferably be constructed of a colloidal substance and should be from 3 to 20 thousandths of an inch in thickness according to the crispness or stiff character of the material used. Compressed fibrous material, such as hot pressed paper or fiber, has been found to act satisfactorily. It will be noted that the arms of the spider J incline downwardly to correspond with the conical shape of the tympanum L and that the apex of the conical portion of the tympanum is pointed upwardly toward the deck A of the cabinet, and that the concave side of the tympanum is open to the surrounding atmosphere through the open bottom of the cabinet, no obstructions being presented to the sound waves issuing from the concave surface of the tympanum.

A cap M is secured to the apex of the conical portion *l′* of the tympanum L, and this cap should be of more rigid construction than the remainder of the tympanum and should preferably be three-eighths of an inch or more in diameter. I prefer to make the cap M of metal, extremely light but very rigid, and in the form of two cones *m*, *m′* screwed tightly together upon opposite sides of the tympanum and gripping with their edges the material of the conical portion of the tympanum. In order that a tight and positive application of the cones forming the cap M to the conical portion of the tympanum may be had, it is preferable to form the cone *m′* of lesser angle than the conical portion of the tympanum, and the cone *m* of greater angle than the conical portion of the tympanum in which case their edges will securely grip the tympanum material when they are secured together. The cap M is applied to the tympanum to receive the shocks which are to be applied to the tympanum as a whole, and convey them to sufficient of the material of the tympanum to insure the movement of the tympanum as a whole. This will be better understood when it is considered that if the shock were applied to paper or hard rubber at a single small point, the inertia of the tympanum as a whole would be sufficient to resist the attack and the material would be distorted or dented at that point, the effect of the shock upon the tympanum as a whole being entirely lost. The cap M being of hard material such as metal will resist the bending action and distribute the shock to so much of the surface of the material of the tympanum as is capable of successfully resisting the shock, and it will then be transmitted to the tympanum as a whole. The plane peripheral portion *l* of the tympanum maintains the place of the conical active portion of the tympanum and yields sufficiently to permit of the required motion of the conical portion, resisting, however, displacement of the conical portion in just that degree neces-

sary to maintain the form and neutral position of the active conical portion. Were the plane peripheral portion *l* of considerably greater width or markedly narrower than described, its function would be destroyed to a degree corresponding to the remoteness of the daparture from the approximate proportion given and the effective portion of the conical portion of the tympanum would be proportionately lessened.

In the tubular arm *g''* of the transmission support G are located two ponderous members or weights N and N'. These members N and N' are shown as insulated from the wall of the arm *g''* by a tube *o* of insulating material, such as soft rubber or felt. One at least of the ponderous members N and N' must be movable relatively to the other and therefore it cannot be rigidly secured to the support G, and the insulating material becomes necessary to avoid rattling. I preferably insulate both of the ponderous members or weights N, N' from the wall of the transmission support G. Pins P projecting from the ponderous member N, and sliding in holes in the other ponderous member N', act as guides and prevent disalinement and angular displacement of the movable ponderous member. Knife edge fulcra *n* and *n'* are secured in and project from the ends of the ponderous members N and N', and in the form of the device shown in Figs. 1 to 9 the fulcra *n* are arranged horizontally and the fulcra *n'* are arranged vertically. A lever Q is mounted on the fulcra *n'* and is capable of movement upon a vertical axis. A style holder *q* projects from the lever Q downwardly at an incline so that the point of a style *q'* held in the style holder is considerably removed from the axis of the lever Q and movement given the style *q'* by the record will effect an oscillation of the lever Q about its vertical axis upon the fulcra *n'*. The lever Q has arms *q''* and *q'''* projecting from opposite sides thereof, the arm *q''* being near the top of the lever Q and the arm *q'''* being near the bottom of said lever. The reason for this arrangement of the arms upon the lever will presently appear.

A lever R is mounted upon the fulcra *n* and oscillates upon a horizontal axis. This lever has arms *r* and *r'* extending upwardly and downwardly from its opposite sides, the arm *r* projecting from a point near one end of the lever R, and the arm *r'* projecting from a point near the other end of the lever R. It will now be seen that a point upon the arm *r* of the lever R is opposite a similar point on the arm *q''* of the lever Q and these two points are connected by rod link S. It will also be seen that a point upon the arm *r'* of the lever R is opposite a point upon the arm *q'''* of the lever Q, and these two points are connected by a rod link S'. The rod links S and S' have eye-ends arranged in planes removed 90° from one another, and these eye-ends *s* are engaged by pivot screws *s'* upon the arms of the levers Q and R. A parallelogram is formed by the levers Q and R and the rod links S and S', and in the form just described, which is adapted for a laterally sinuous groove in the record, oscillation of the lever Q about a vertical axis will produce like oscillations of the lever R about a horizontal axis. Springs T preferably mounted upon the pins P press the ponderous members N and N' apart forcing the knife edge fulcra *n* and *n'* tightly against the levers R and Q, and put the parallelogram of levers and links under tension, precluding any rattle or looseness of the levers upon the fulcra or of the eye-ends of the links upon their pivot screws, and as the movable ponderous member of the combination is insulated from the transmission support G, no rattle or displacement of the parts can take place when the record groove oscillates the lever Q, but such oscillation will be faithfully transmitted to the lever R. The ponderous members N and N' have clearance holes *s''* for the rod links S and S'.

An arm U projects from the central portion of the lever R and to its end is rigidly secured a rod V which extends downwardly through the interior of the arm *q* of the transmission support G, its lower end being rigidly secured to the cap M of the tympanum. The rod V is nicked or thinned at *v* close to the arm U of the lever R to permit of a slight springing action which compensates for the very slight angular motion of the arm U when the lever R is oscillated. It will now be seen that the oscillation of the lever R about its horizontal axis imparted to it from the lever Q, will effect an endwise vibration of the rod V which is directly impressed upon the tympanum L. A cap W closes the opening at the angle of the transmission support G and the removal of this cap gives access to the working parts of the rear end of the transmission.

It will be noted that the distance between the point of the style *q'* and the axis of the lever Q is greater than the length of the arm U which projects from the center of the lever R and to which the rod V is connected. By reason of this fact, and of the fact that the levers Q and R, and the rod links S, S' form a parellelogram, the length of vibration of the tympanum is relatively much less than that of the style, and the tympanum thus offers little resistance to the movement of the style, thereby greatly reducing the wear on the record. To compensate for this small movement of the tympanum, its large area enables it to move a large body of air, so as to obtain sound waves of large volume and great carrying power.

When a vertically sinuous record is em-

ployed the lever Q is mounted to oscillate about a horizontal axis, as shown in Fig. 10, no change in the lever R being required.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is:—

1. In a machine for directly regenerating sound from a record of the same, a vibratile conical tympanum of large area rigidly supported at its periphery and freely exposed to unconfined air, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum; the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

2. In a machine for directly regenerating sound from a record of the same, a vibratile conical tympanum of large area rigidly supported at its periphery and freely exposed to unconfined air, a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves, and an open-work cabinet inclosing the tympanum but affording substantially free access of the surrounding air thereto; substantially as described.

3. In a direct sound regenerating machine, the combination of a record holder, a transmission support mounted to swing over said record holder, and a tympanum carried by said support and extending under said record holder; substantially as described.

4. In a direct sound regenerating machine, the combination with a record holder, of a transmission support mounted to swing about vertical and horizontal axes, said support having an arm extended to move above and across said record holder and adapted to carry a stylus, the support having a second arm having a free end, and a tympanum carried at the free end of said second arm with its axis at an angle to said first arm; substantially as described.

5. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram having opposite sides mounted on said fulcra and means exerting pressure upon said ponderous members to place said parallelogram under tension; substantially as described.

6. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram of non-extensible links and non-flexible levers, the levers of said parallelogram being mounted on said fulcra, and means exerting pressure upon said ponderous members to place said parallelogram under tension; substantially as described.

7. In a machine for directly regenerating sound from a record of the same, a tympanum support having a circular aperture, a light vibratile tympanum of long area having its outer edge rigidly mounted in said support, said tympanum being shaped to provide an annular sustaining rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

8. In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture, a light tympanum of long area having its outer edge rigidly mounted upon said support in said aperture, said tympanum having a central conical portion, the base of which exceeds in area one half the effective area of the said tympanum and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

9. In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture, a light vibratile tympanum exceeding nine inches in diameter, having its outer edge rigidly mounted on said support, said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, whereby the tympanum imparts to the surrounding free air sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

10. In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular

aperture exceeding nine inches in diameter, a light vibratile tympanum mounted in said aperture and having its outer edge rigidly secured upon said support, said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the diameter of the said circular aperture in said support, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

11. In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture, a light vibratile tympanum of long area mounted in said aperture, and having its outer edge rigidly secured to said support, said tympanum being shaped to provide an annular rim adjacent said support, the outer diameter of said rim exceeding nine inches, and a conical portion springing from the inner edge of said annular rim, the altitude of said conical portion being substantially one fourth of the diameter of its base, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, the tympanum being of sufficient area to impart to the surrounding free air, when the tympanum is so vibrated, sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

12. In a machine for directly regenerating sound from a record of the same, a ponderous tympanum support having a circular aperture exceeding nine inches in diameter, a light vibratile tympanum mounted in said aperture, and having its outer edge rigidly secured to said support, said tympanum being shaped to provide an annular rim adjacent said support, and a conical portion springing from the inner edge of said annular rim, the diameter of the base of said conical portion being not less than eight-tenths of the diameter of said circular aperture in said support, and the altitude of said conical portion being substantially one quarter of the diameter of its base, a cap of non-vibratile material rigidly secured to the apex of said conical portion of said tympanum, and a mechanical transmission through which the vibrations produced by the record are transmitted to the tympanum, whereby the tympanum imparts to the surrounding free air sound waves substantially corresponding in intensity to the recorded sound waves; substantially as described.

13. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, and a style holder carried by one of said levers; substantially as described.

14. In a sound regenerating machine, a vibration transmission comprising two ponderous members, guides for maintaining the relative positions of said members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, and a style holder carried by one of said levers; substantially as described.

15. In a sound regenerating machine, a vibration transmission comprising two ponderous members, guides for maintaining the relative positions of said members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, and a style holder carried by one of said levers; substantially as described.

16. In a sound regenerating machine, a vibration transmission comprising two ponderous members, a vertical fulcrum on one of said members, a horizontal fulcrum on the other of said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, and pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension; substantially as described.

17. In a sound regenerating machine, a vibration transmission comprising two ponderous members, fulcra carried by said members, an articulate parallelogram of links and levers, the levers of said parallelogram mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, a style-holder carried by one of said levers, a direct sound regenerating tympanum connected to another of said levers and a pivoted support for said transmission and said tympanum; substantially as described.

18. In a sound regenerating machine, a vibration transmission comprising a support, two ponderous members carried by said support, one of said members being movable upon said support, insulating material between said movable member and said support, fulcra carried by said members, an articulate parallelogram of links and levers, said levers being mounted on said fulcra and pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension; substantially as described.

19. In a direct sound regenerating machine, the combination of a bottomless cabinet having apertures on all sides and a horizontal partition therein, a record holder mounted upon and above said partition, a motor for driving said record holder, a right angled transmission support mounted to swing upon horizontal and vertical axes upon said partition adjacent the periphery of said record holder, one arm of said support adapted to be swung over said record holder, and the other arm of said support extending downwardly through said partition, a vibration transmission mounted within and insulated from said transmission support and comprising two ponderous members carrying fulcra, a parallelogram of links and levers, said levers mounted upon said fulcra, pressure exerting means acting between said members and tending through said fulcra to hold said parallelogram under tension, a style-holder carried by one of said levers at the outer end of said transmission support, a spider mounted upon said transmission support below said partition, a ponderous tympanum support carried by said spider, a direct sound regenerating tympanum mounted upon said ponderous tympanum support, said tympanum being of light vibratile material and having a conical form throughout the greater part of its area and a positive connection between the apex of the conical portion of said tympanum and the inner end of the parallelogram of the said vibration transmission; substantially as described.

20. In a sound regenerating machine, a tympanum, a vibration transmission tensioned in the direction of its vibration independently of the tympanum and connected therewith, and a style holder connected with said transmission.

21. In a sound regenerating machine, an untensioned tympanum, a vibration transmission tensioned in the direction of its vibration and connected with said tympanum, and a style holder connected with said transmission.

22. In a sound regenerating machine, a tympanum, an oscillatory transmission member connected therewith, a style holder for oscillating the transmission member, and means independent of the tympanum for tensioning the transmission member in the direction of its oscillatory movement.

23. In a sound regenerating machine, a tympanum, an oscillatory transmission member connected therewith, a style holder for oscillating said member, and means independent of the tympanum for yieldingly imparting a tension to said member in the direction of its oscillatory movement.

24. In a sound regenerating machine, an untensioned tympanum, a transmission member connected therewith and adapted for oscillation, a style holder for oscillating said member, and means for imparting a tension to said member in the direction of its oscillatory movement.

25. In a sound regenerating machine, a style holder, a tympanum having a rigid vibratory portion, and a tensioned transmission connecting the style holder with said rigid portion, the tension of said transmission being in the direction of its vibration and independent of the tympanum.

26. In a sound regenerating machine, a style, a tympanum, and tensioned transmission means connecting the style and tympanum and having means for imparting vibrations to the tympanum having no greater length than the vibrations of the style, the tension of said transmission being in the direction of its vibrations and independent of the tympanum.

27. In a sound regenerating machine, a tympanum having a vibratile area of sufficient size to effect, without amplification, the regeneration from a record of sound waves of relatively large volume and carrying power, and tensioned vibration transmitting means connected to the tympanum and adapted to be actuated by a style, the tension of the transmission being in the direction of its vibration and not extending to the tympanum.

28. In a sound regenerating machine, a tensioned vibration transmission, a style-holder upon one end of said transmission and an untensioned tympanum connected with the opposite end of said transmission, the tension of the transmission being in the direction of its vibration; substantially as described.

29. In a sound-regenerating machine, a vibratile conical tympanum of large area rigidly supported at its periphery and freely exposed to unconfined air, a sound-vibrated element, and vibration transmission means connecting said element and said tympanum and arranged to impart to the tympanum vibrations which are relatively much shorter than the vibrations imparted to the said element.

30. In a sound-regenerating machine, a vibratile conical tympanum rigidly supported at its periphery and freely exposed to un-

confined air, a sound-vibrated element, and vibration transmission means connecting said element and said tympanum arranged to impart to the tympanum vibrations which are relatively much shorter than the vibrations imparted to the said element; the tympanum having an area sufficiently large to effect, without amplification, sound waves of large volume and carrying power.

31. In a sound-regenerating machine, a vibratile conical tympanum of large area, rigidly supported at its periphery and freely exposed to unconfined air, a sound-vibrated element, and tensioned transmission means connecting said element and said tympanum and arranged to impart to the tympanum vibrations which are relatively much shorter than the vibrations imparted to the record end of the style.

In testimony whereof I affix my signature in presence of two witnesses.

MARCUS C. HOPKINS.

Witnesses:
M. A. BILL,
LEON W. ROSENTHAL.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."

Corrections in Letters Patent No. 1,271,527.

It is hereby certified that in Letters Patent No. 1,271,527, granted July 2, 1918, upon the application of Marcus C. Hopkins, of Jersey City New Jersey, for an improvement in "Sound-Regenerat ng Machines," errors appear in the printed specification requiring correction as follows: Page 1, line 25, for the word "magaphone" read *megaphone;* page 5, lines 75 and 95, claims 7 and 8, and page 6, line 25, claim 11, for the word "long" read *large;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of September, A. D., 1920.

[SEAL.]

M. H. COULSTON,
Acting Commissioner of Patents.

Cl. 274—16.

1913

CONTENTS:

1. Application ..... 1 papers.
2. Rejection Sept 9. 13
3. Amdt A Emp Oath Dec 24/13
4. Rej Feb 7, 1914
5. Amdt. B Feb 6/15
6. Rej Feb 23, 1915
7. Amdt. C Feb 23/15
8. Rej March 4, 1916
9. Appl dt. J. Mar 29/16
10. Letter April 1, 1916.
11. Amdt E Apl 6/16
12. Remarks Mar 22/18
13. Amdt F. 3/29/18
14. Ltr Apr. 5 1918
15. Letter Gen address 4/8/18
16. Amdt G. 4/15/18
17. Notice of Suit Nov. 12-1924
18. Notice of Suit Feb. 18-1925
19. Notice of Suit May 26-1925
20. Notice of Suit Nov. 3-1925
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M. C. HOPKINS.

SOUND REGENERATING MACHINE.

APPLICATION FILED JULY 14, 1913. RENEWED MAR. 22, 1918.

1,271,527. Patented July 2, 1918.

5 SHEETS—SHEET 1.

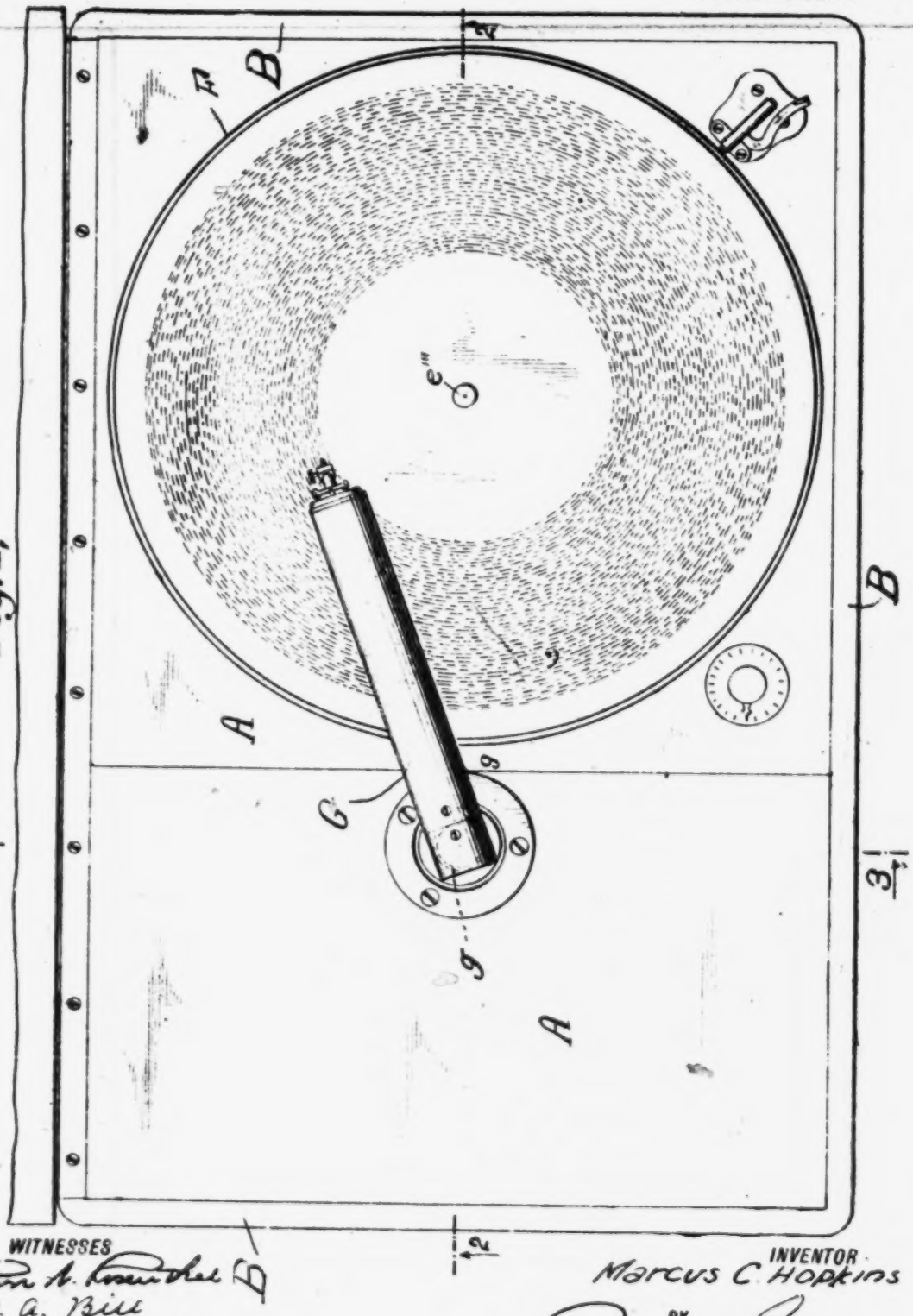

Fig. 1.

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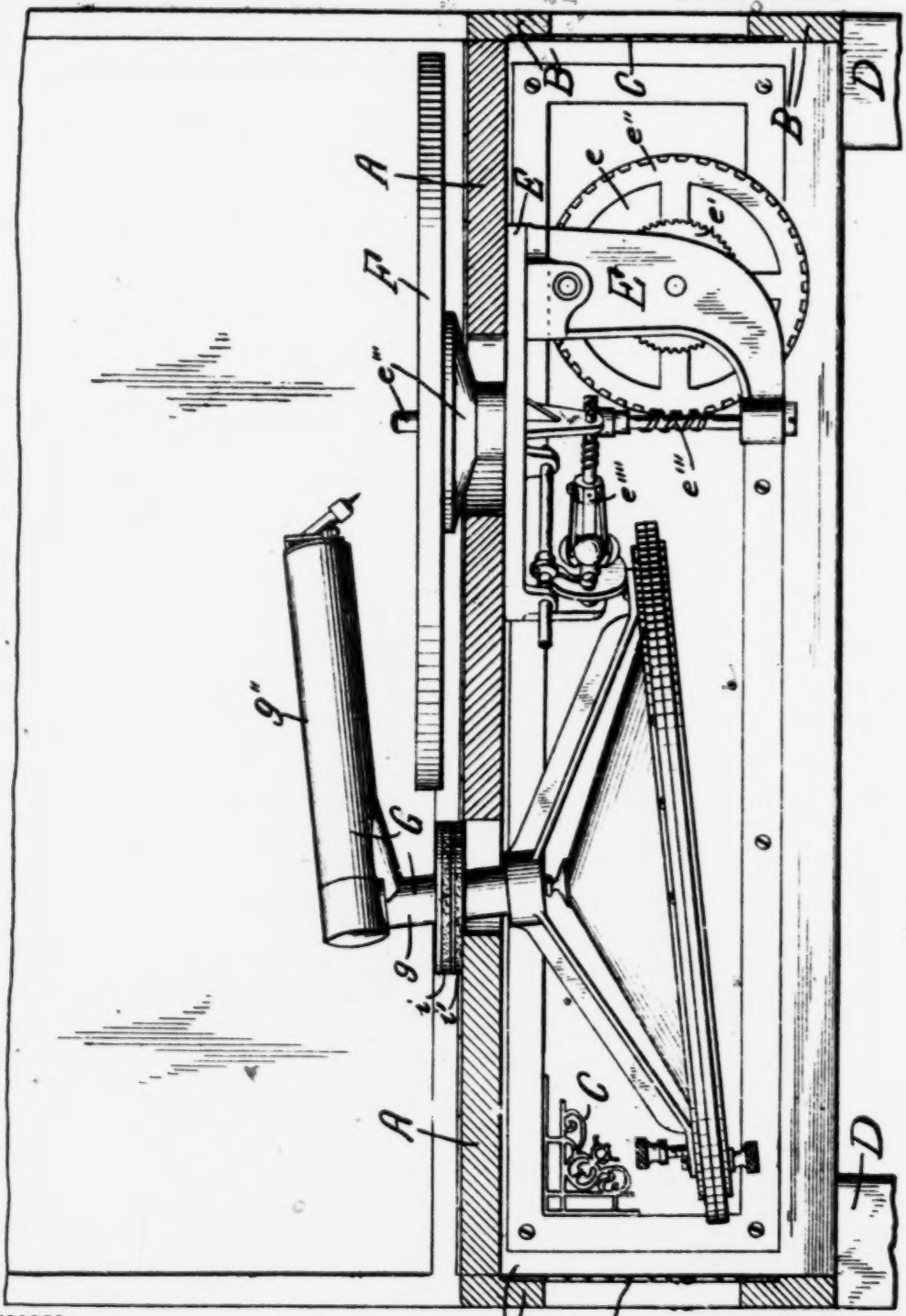
5 SHEETS—SHEET 2.

Fig. 2.



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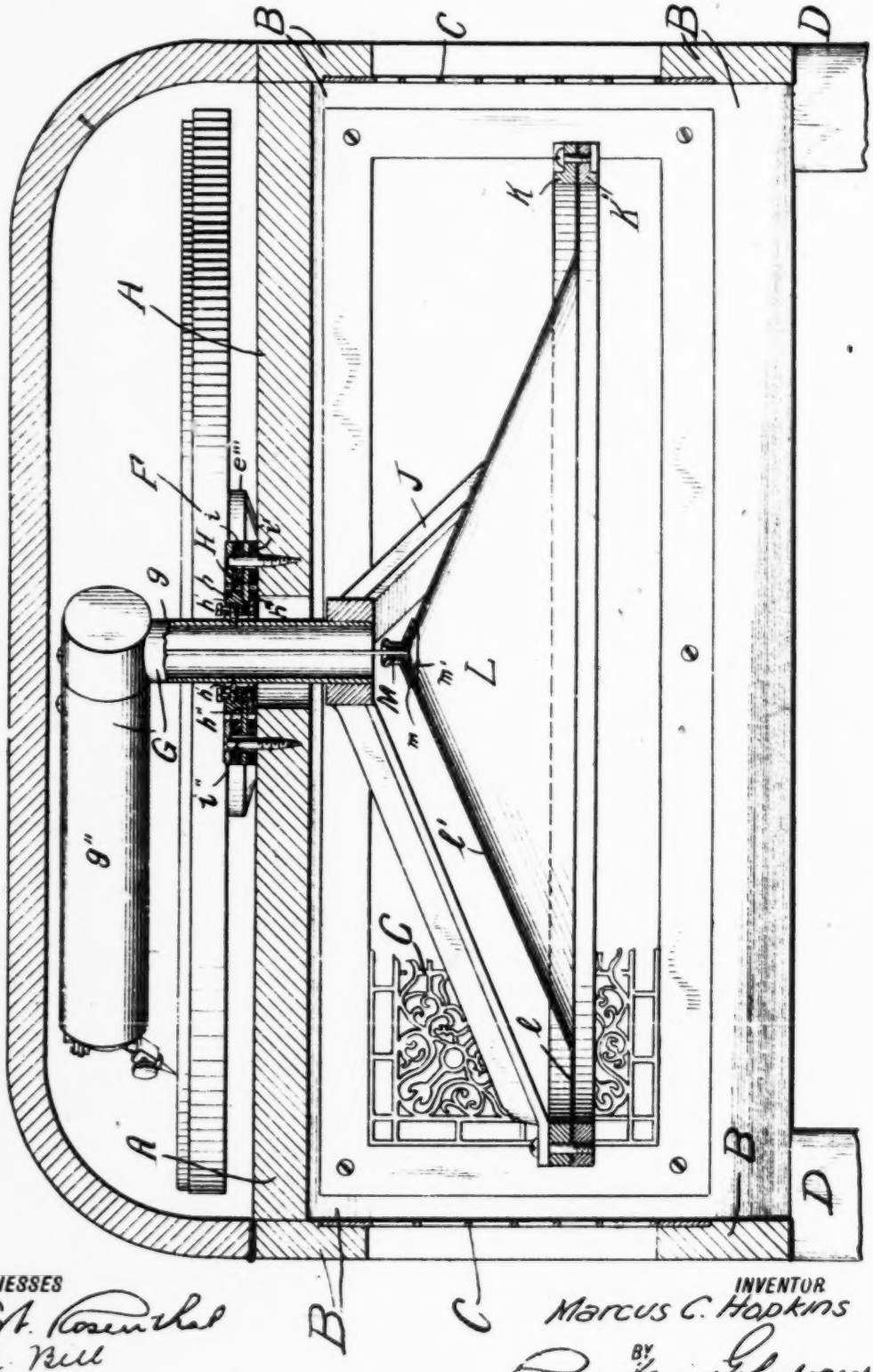
1,271,527. Patented July 2, 1918.

5 SHEETS—SHEET 3.

Fig. 3.



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SOUND REGENERATING MACHINE.

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5 SHEETS—SHEET 4.

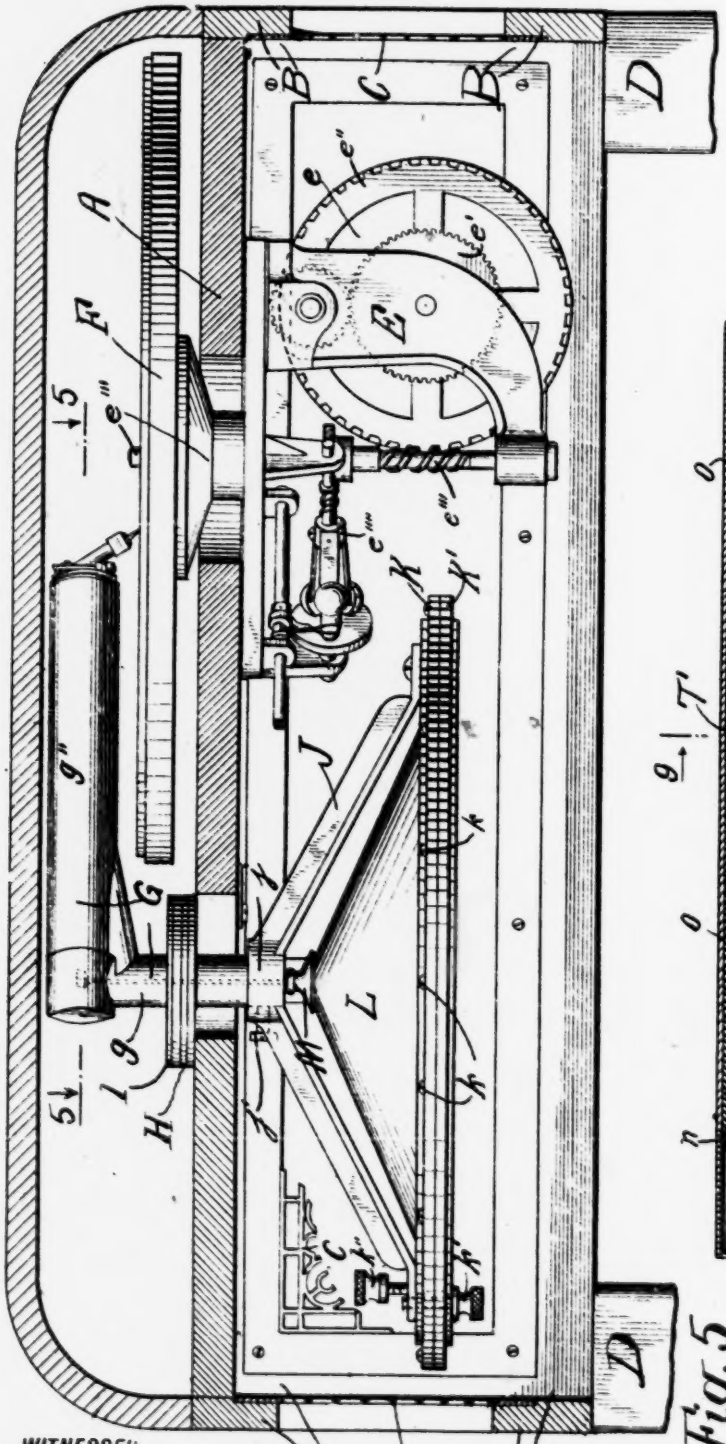

Fig. 4.

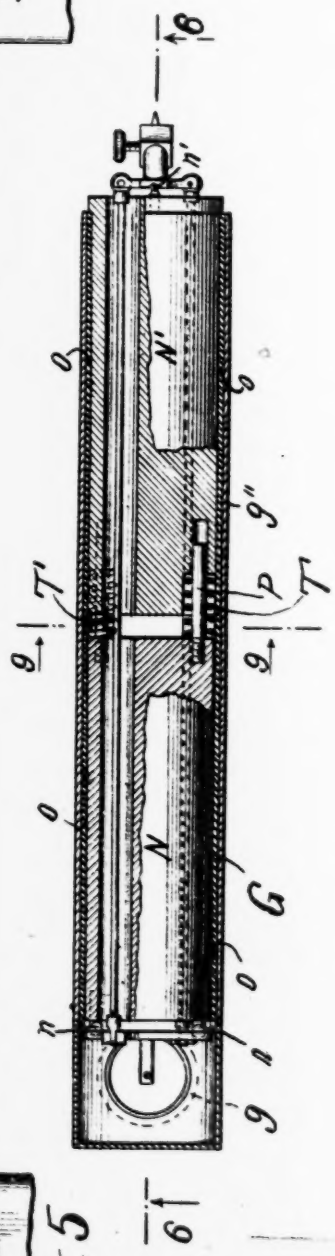

Fig. 5

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5 SHEETS—SHEET 5.

Fig. 8,

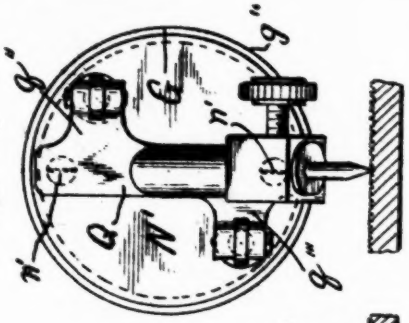

Fig. 10,

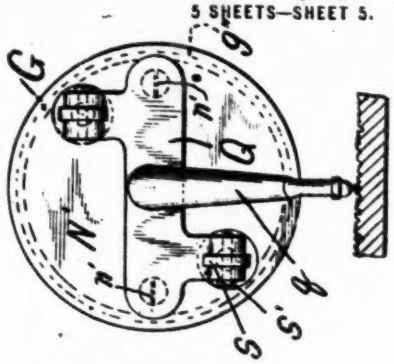

Fig. 6,

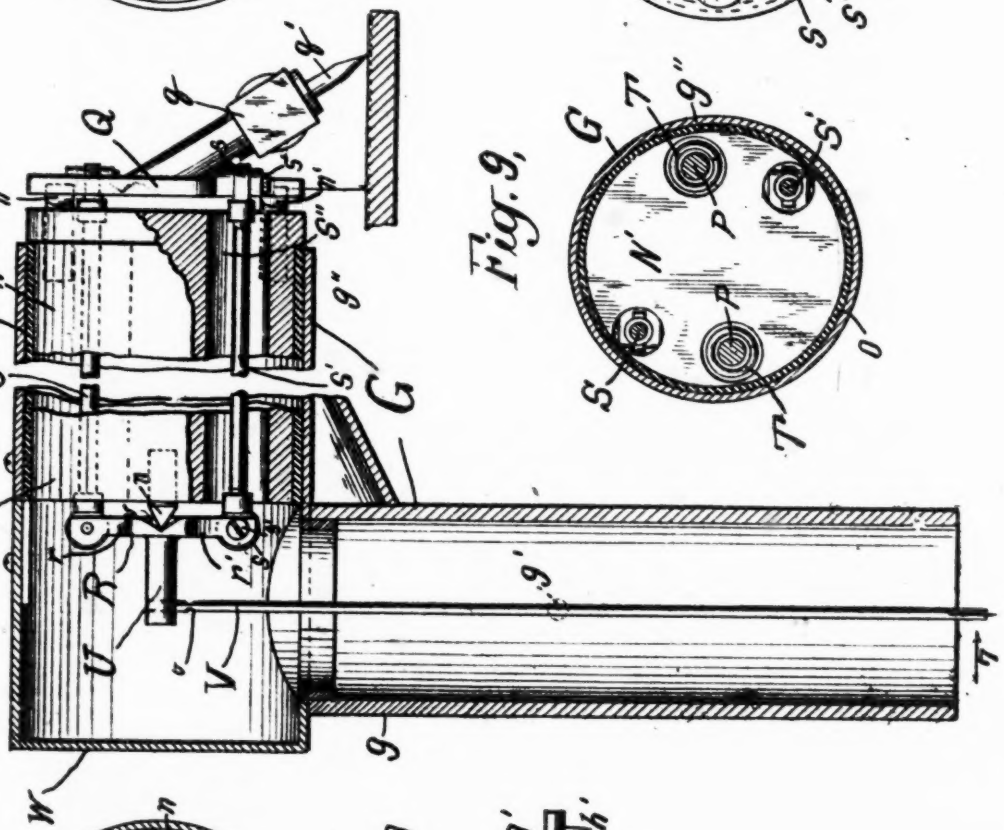

Fig. 9,

Fig. 7,

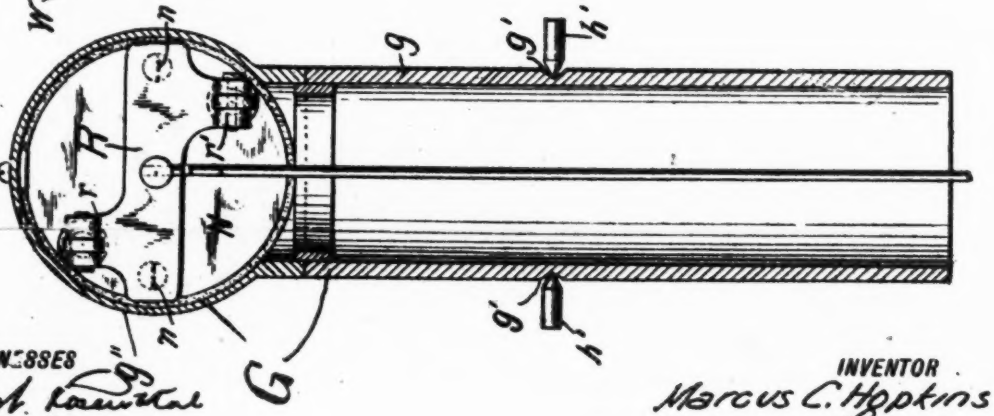

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Fig. 1,

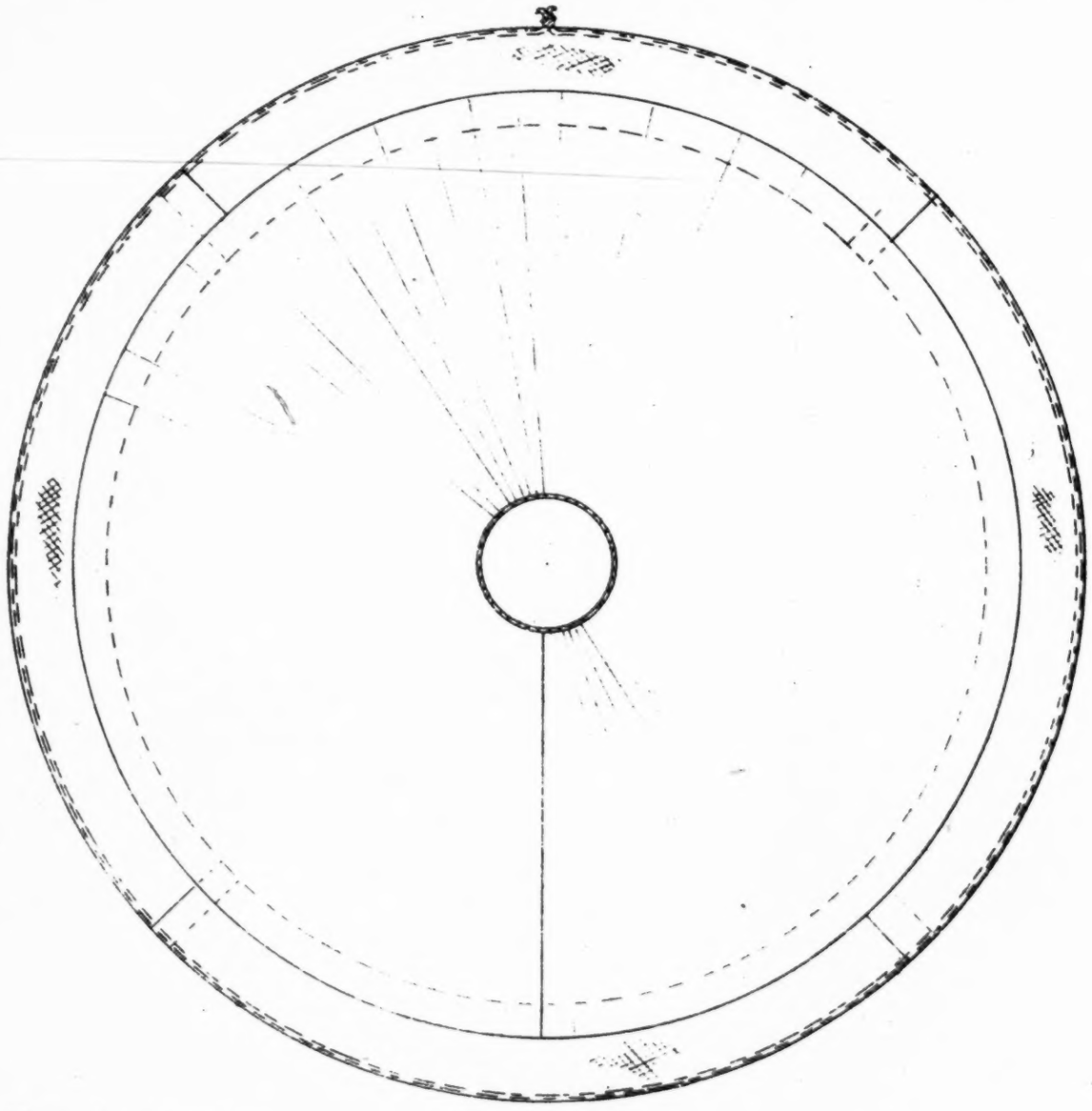


Fig. 3

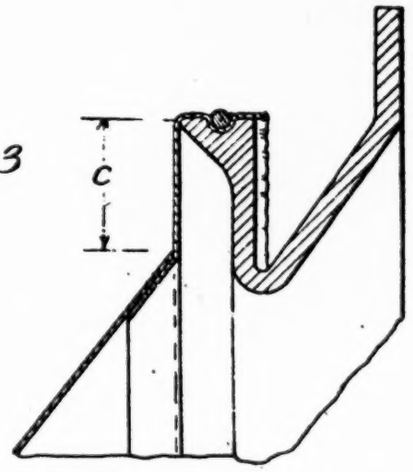
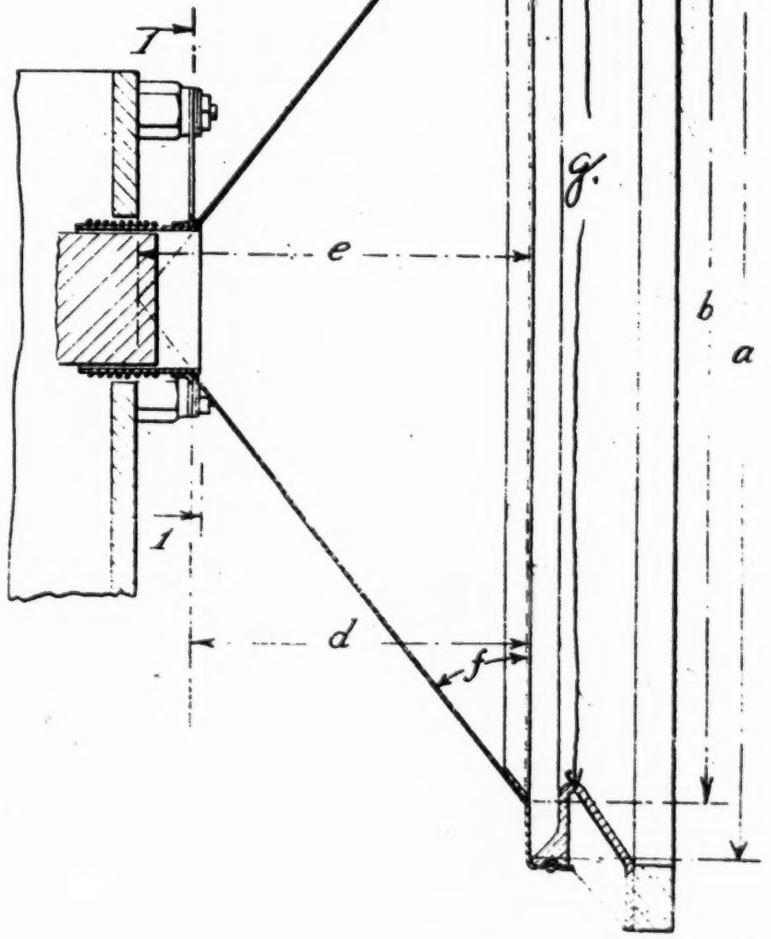


Fig. 2,



Small Speaker		Large Speaker	
a =	8"	a =	9½"
b =	7"	b =	8½"
c =	½"	c =	½"
d =	2⅜" } variable with atmospheric cond.	d =	3½" } " " " " "
e =	2¾" }	e =	4" }
f =	38°	f =	43°

The angle "f" of a cone whose altitude is one-fourth of diameter of its base is 26 degrees 34 minutes

Arendt Drawing Showing Dimensions of Defendant's Loud Speakers.

Fig. 1,

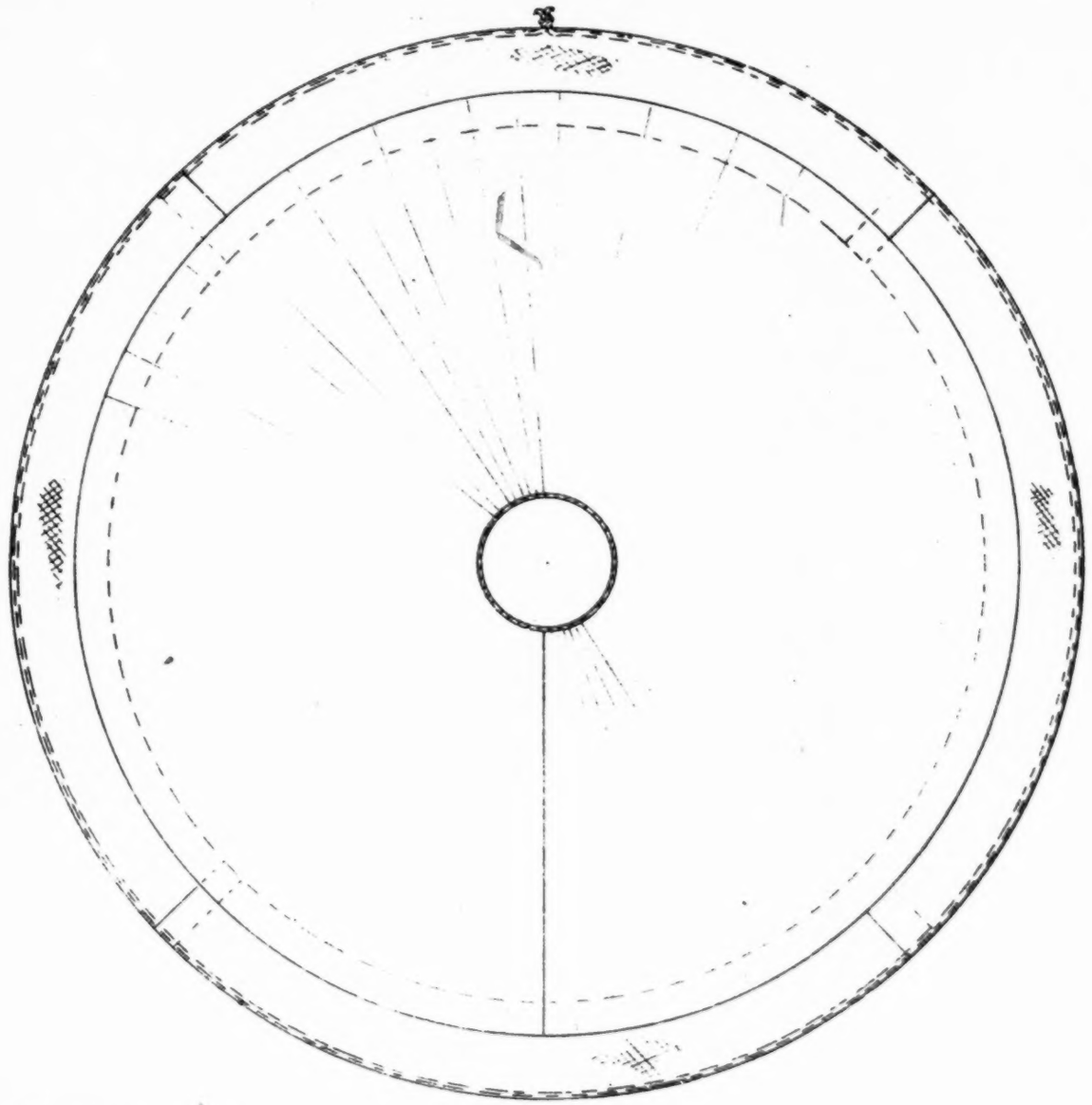


Fig. 3

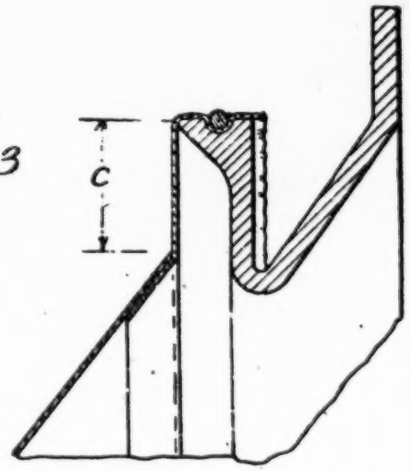
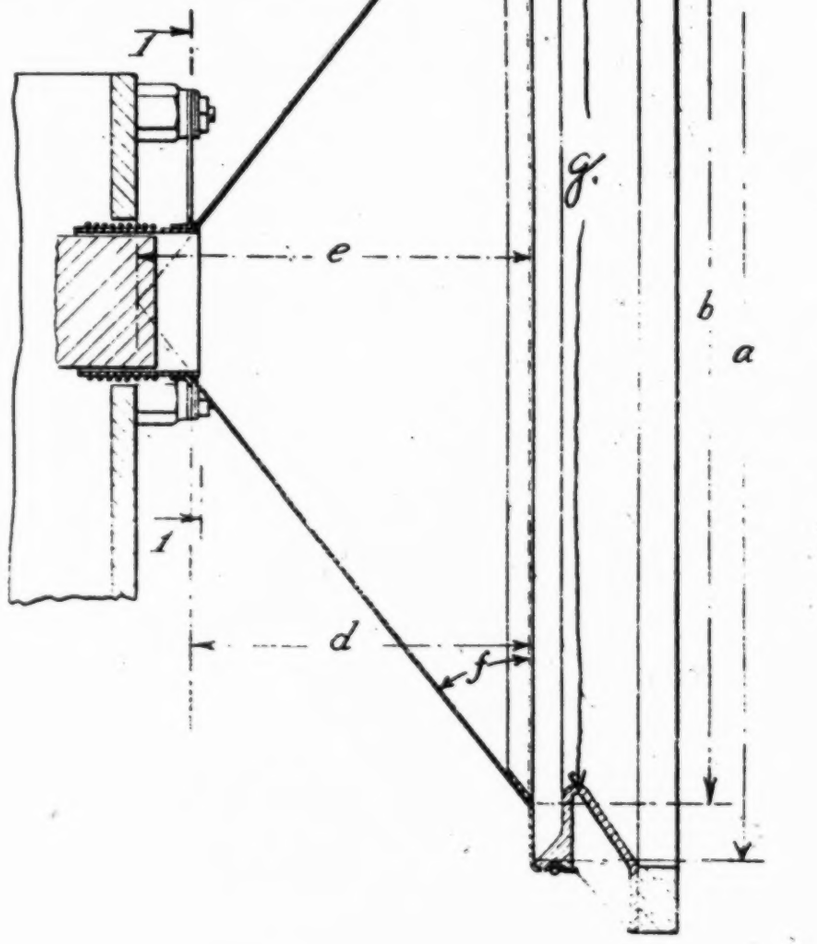


Fig. 2,



Small Speaker		Large Speaker	
a =	8"	a =	9½"
b =	7"	b =	8½"
c =	½"	c =	½"
d =	2⅜" } variable with atmospheric cond.	d =	3½" } " " " "
e =	2¾" } " " " "	e =	4" } " " " "
f =	38° "	f =	43°
g =	6 25/32 "	g =	8¼"

The angle "f" of a cone whose altitude is one-fourth of diameter of its base is 26 degrees 34 minutes

PROCEEDINGS

of the

RADIO CLUB OF AMERICA

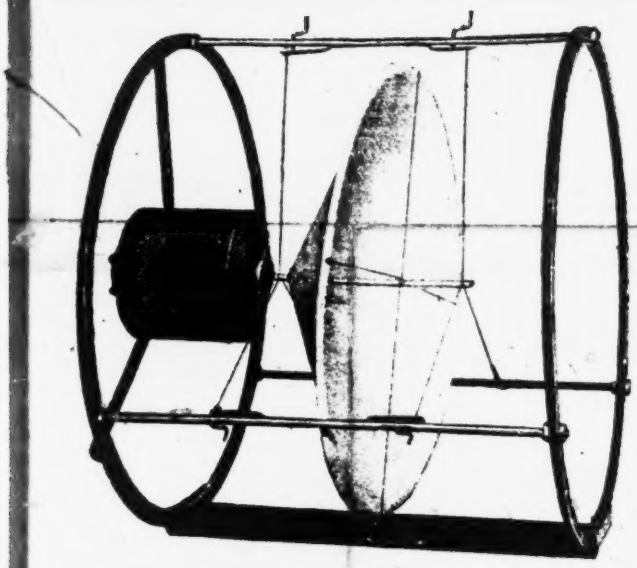
Cone Loud Speakers

A Paper Delivered Before the Radio Club of America on January 27, 1926

By C. L. Farrand

President, Farrand Mfg. Co., Inc.

Volume 3, No. 10 October, 1926



A FREE EDGE CONE DEVICE

In this instance the cone was mounted on a paper straw, and reinforced by silk threads from the straw to its periphery. Bobbin motions as large as one-eighth of an inch were sometimes noticed with this instrument

Cone Loud Speake

A Radio Club of America Paper Whic Tells of the Development of the Con Type Loud Speaker—The Requirements of a Cone to Reproduce Equally the Whole Audio Frequency Range—Where to Look for Distortion When It Occurs

By C. L. FARRAND

President, Farrand Mfg. Co., Inc.

DEVICES used in the process of converting sound into electrical energy cannot always be used for the reverse process—to convert electrical energy into sound, that is. This is especially true in the case of the common carbon microphone. However, the condenser microphone, to cite one concrete example, is a very satisfactory converter of electrical energy into sound, provided the energy is not considerable. If an attempt be made with this device to obtain the same amplitude of sound as the original input (into the transmitter of a broadcasting station, for example), an electrical rupture will occur. This is due to the low efficiency of the device, and to the low insulation resistance made necessary by the very close spacing of the opposite plates of the condenser microphone. The conversion efficiency of these devices is very low, the electrical output being very small.

Certain types of microphones (better styled "pickups") may be reversed, providing the amplitude is already within the working limits.

For the true conversion of sound into electrical energy, or vice versa, three conditions are necessary. First, we must provide a surface in the wave front of the sound wave which will move in accordance with the sound wave; second, adapt this surface to actuate or control an electric or magnetic field; third, arrange the field so it can be utilized for the production of the necessary voice currents.

The construction of the field and its associated circuit presents but a small problem, while the construction of the moving surface and its supports presents many mechanical difficulties. A disc, secured at its edge, as in the form of the present day telephone, has the disadvantages of stresses in the metal permitting the center portion to deflect a relatively large amount while the edge is stationary. This gives rise to mechanical period in the diaphragm itself, which is ultimately imparted to the associated electrical system. In the development of the telephone it became evident that it would be desirous to have the surface of the diaphragm move [illegible]

Cone diaphragms were used in telephones and were sometimes used in connection with horns as loud speakers. The action of the diaphragm of a plunger was to change the volume of the air in the sound box and force a high amplitude sound wave from the orifice into the horn, while the old style diaphragm changed the volume of air in the sound box by flexing. The usual difficulties of sound box resonance were present, and the addition of the horn added certain resonant periods.

THE REQUIREMENTS OF A GOOD HORN

MUCH time and effort have been applied to the development of horn loud speakers for phonograph and radio purposes. Horns of small size have been made which cover only a small portion of the frequency range. A horn, to reproduce music successfully, should cover a frequency range of 50 cycles to 6000 or 8000 cycles. This can be partially accomplished by a horn of large size, *i. e.*, 6 or 8 feet in diameter and of about the same length. Horns of smaller size generally cover the upper range or the middle range, and depend upon internal resonance to develop the lower notes.

In order to approximate a reasonable range, several horns can sometimes be used in combination. One horn would be designed for the upper range while one or two horns would be designed to cover the middle and lower ranges. The results obtained from devices of this kind have been only partially satisfactory, as a great many resonant periods occur, which tend to accentuate or blur certain tones.

The conical diaphragm, when used in telephone sound boxes, presented different problems than when it was freely exposed to the surrounding air. Hopkins made a large step in this direction by evolving a practical conical diaphragm of sufficient size to produce a sound wave of magnitude comparable to the original sound, without the use of a horn. This was successfully used with a phonograph. Large diaphragms of this character will produce a sound wave of magnitude of a normal speaking voice with a small amplitude of motion. To produce the same magnitude of sound with a small diaphragm and horn, requires a much larger amplitude of motion and higher [illegible]

mately the same amplitude as the wave prod by the large diaphragm.

The author, while searching for a suit loud speaker in connection with talking pic work and wireless telephone systems, and w ing to avoid the distortion of the horn, happe upon the Hopkins conical diaphragm, and c bined it with suitable actuating electrical phone mechanisms. The advantages of a phragm of this type for use as a loud spe were investigated and developed. A co diaphragm can be constructed so that it m substantially as a plunger at sound freque By so moving, it acts upon a large area volume of air, and produces a high power wave of large amplitude, with slight motio

It may be generally stated that the cone m as a plunger at sound frequency. This, howe is not exactly the case. A cone of a given will move as a plunger only if the frequen sufficiently low. As the frequency is increa the outer portion of the cone will tend to re stationary, and, at extremely high freque only the inner portion of the cone will m If a cone is built several feet in diameter center portion of the cone will act at the hi frequencies, around 3000 to 5000 cycles, w as the frequency is lowered, the active ar the cone will progressively increase. Thi at the lower tones, a larger portion of the will function. It was noticed in the use of l cones that there was a greater tendency t produce the lower frequencies, or bass notes it seemed that there was a relation betwee diameter of the cone and the length of the w It is not unreasonable to expect that a 10 sound wave can be better produced by a pla which approximates that diameter than by only a small fraction of that size. Such a phragm may be likened to an antenna, and as a radiator. With suitable proportion, it approach an aperiodic radiator. By redu the mass of the diaphragm and the elasticit the suspension, and disassociating it from t mechanical portions of the system, it will proach the true conditions of aperiodicity. is essential that the associated telephone m ment does not upset this condition by ha undue mass or elasticity. The mass and e ticity should be so proportioned that they do appreciably reduce the natural damping of diaphragm. A diaphragm of this character an extremely large resistance to motion, w is due to the actual production of sound a

the conical shape gives extreme rigidity to [illegible]

duced, that is, for efficient radiation, it is desirable to have an antenna length which is an appreciable fraction of the maximum wavelength to be radiated from the antenna system.

THE MOVING COIL SYSTEM

THE moving coil telephone is ideal for the purpose of producing a highly damped ·or, as the mass of the coil can be made very low, and the elasticity is only that of the diaphragm, which is extremely small.

The next in choice is the balanced armature telephone. The latter generally requires a reduction lever to reduce the amplitude motion of the armature to a lower motion for application to the apex of the conical diaphragm. A reduction ratio between 0.8 and 0.4 to 1.0 is generally satisfactory.

The moving coil system, with a large conical diaphragm, was developed commercially by the author in the form of the Phonetron of 1921, and used for both loud speaker and pickup purposes.

Fig. 3 is a photograph of one of the original Phonetrons, while Fig. 1 shows its constructional details. The conical diaphragm was supported at its edge by two clamping rings. To these two clamping rings, and located on the axis of the cone, was secured an electro-magnet, by means of a spider-like support. The electro-magnet was pot-like in shape, made of cast iron or steel with a central core of Norway iron, and provided with a field winding of No. 18 B. & S. wire (suitable for 6-volt operation), and thus produced a uni-directional annular field. A cylindrical bobbin of hard rubber was supported from the apex of the cone so as to move freely in the annular field without touching the metal portions of the magnet. This bobbin was wound with 0.002-inch diameter enameled wire, about 4500 turns, for use directly in the plate circuit of a vacuum tube. Fewer turns, together with a transformer, were sometimes used. The apex of the cone was stiffened by means of thin conical metal reinforcements. When used as a pickup, the construction was similar. The Phonetron pickups were installed in the original WJZ station in Newark, New Jersey, and were used there during the spring of 1922 with excellent results. Unfortunately the receiving equipment at that time did not permit the broadcast listener to appreciate the quality of transmission. A receiver utilizing a practically distortionless amplifier and Phonetron loud speaker was installed in the office of John V. L. Hogan in New York City. Tests were made between this receiving station and WJZ of Newark, and various comparisons of pickups and loud speakers were made. The amplifier used in connection with this early work was a resistance-coupled audio-frequency amplifier wherein only the alternating potential of the plate is supplied to the succeeding grid by means of a balancing battery, which balances the d. c. potential of the plate. This circuit is shown in Fig. 2. This amplifier, I believe, is due to Arnold of the Western Electric Company. It is very satisfactory for experimental purposes where it is desired to have distortionless amplification of all sound frequencies. Four resistance-coupled stages will give an amplification equivalent to about two stages of efficient transformer coupling. The new Radio Corporation and Cunningham power tubes, UX and CX 112, are satisfactory for this type amplifier. The purpose of making the resistance of the first stages larger is to decrease the operating voltage on the tube and to permit a smaller balancing battery which balances the operating voltage of the tube to be used. An amplifier of this kind will amplify from zero cycles to 25,000 cycles without distortion, there being no reactance, either capacitative or inductive, to introduce a frequency function. Figs. 4 and 6 are photographs of a battery balanced amplifier of this type built for laboratory purposes.

CHOOSING PAPER FOR A CONE

IN THE development of the cone loud speaker, many different types of construction were tried. Various materials, including hard rubber, celluloid, wood, metals, paper, etc., were tried for the cone. A fibrous paper, not highly calendered, operates satisfactorily, and presents a good commercial solution. The thickness of the paper should be approximately one mil (.001") for each inch of diameter, providing a soft finish paper is used; the thickness should be less if the paper is hard finish. The harder the finish of the paper, the greater will be found the tendency to depart from the cone shape, and undue stress will be set up in the paper, which will give rise to rattles, due to "tin-can" actions. The proportion of the altitude of the cone to its base can be gauged by the angle of the side of the cone to its axis. This should range between 30 degrees and 60 degrees. These values are approximate, and depend upon the size of the cone, and may be deviated from without affecting operation to any large extent.

The freedom of movement, of course, is hindered somewhat by the flexing of the paper at the edge. This flexing involves a loss of power which can be compared to hysteretic losses. Experiments were conducted to determine the amount of these losses and to lessen them. Sandpapering an annular portion at the edge of the cone, or substituting light flexible paper or other material, and castellating the paper edge, were tried. Where heavy paper was used, the above experiments improved the results, and were manifested by an increased clarity of treble. Complete freedom of the edge was obtained by suspension of the cone on silk thread. The photograph at the top of page 514 is of the free cone device. The cone was mounted on a paper straw, and reinforced by silk threads from the straw to its periphery. On one end of the straw was mounted a bobbin which floated in the annular field produced by the electro-magnet. The complete assembly was supported by threads. There was nothing to retard the axial motion of the bobbin; it floated freely in the sound wave, and motions as large as $\frac{1}{8}$th of an inch were sometimes noticed when used.

As this was done, it was found that the edge of the cone, due to the slowness of curvature, was not inclined to move integrally with the rest of the cone. This was overcome by making a circular trough-like portion at the edge, which reinforced it, and retained the circular form of the cone. A method nearly as effective is to reverse a small portion of the cone at the edge, making a V shape trough instead of the circular trough. The advantages of freeing the edge of the cone are so slight that operation can be equaled by suitable proportion, while the mechanical advantage of a supporting ring at the edge of the paper are apparent. The outer portion of the cone can be conveniently turned inward and the mass of the supporting rings and its supports materially reduced without affecting its operation.

Fig. 5 shows a photograph of a large cone speaker built in experimental form. The mechanism is substantially the same as that of the Phonetron, shown in Fig. 1, and consists of a floating coil supported from the apex of the cone and which floats in the annular, uni-directional magnetic field. The cone of this model was about four feet in diameter, and was made of pieces of wood cemented together. The

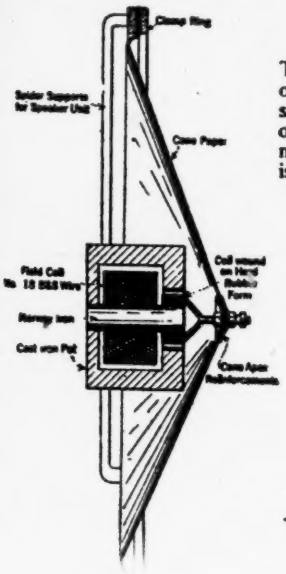


FIG. 1
The construction of the Phonetron, shown at the other lower corner of this page, is made clear by this diagram

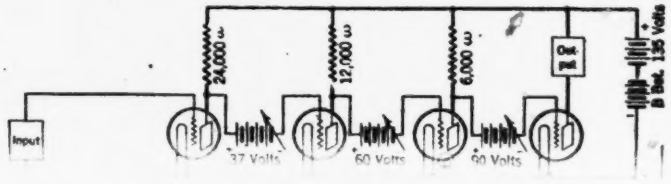


FIG. 3
In 1921, a moving coil system, with a large conical diaphragm, was developed. It was known as the Phonetron

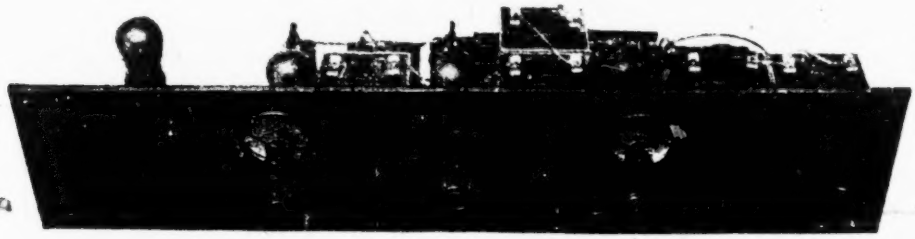


FIG. 4

A battery balanced amplifier as used in the experiments between New York and WJZ of Newark in 1922. It is a resistance-coupled affair wherein only the alternating potential of the plate is supplied to the succeeding grid by means of a balancing battery, which balances the d.c. potential of the plate

periphery of the cone was cemented to a ring of canvas which in turn was cemented to a square plywood board. The action of this device, as in the case of the Phonetron cone speaker, is as follows: The armature coil is drawn inward toward the field magnet when the voice current is in one direction, and forced outward from the magnet when the voice current reverses to the opposite direction. In this way, the force is applied between the apex of the cone and the heavy magnet pot without a system of mechanical levers.

The loud speaker, being the device which produces the sound, is generally blamed for all the deficiences of the receiving system, including those due to poor receiver, vacuum tubes, batteries, and at times, even the deficiencies of the broadcasting.

The better grade of receiver of to-day contains good audio transformers and is capable of producing good quality music with sufficient bass. It is, however, necessary that the batteries have voltage to supply sufficient power to the vacuum tubes. It is also necessary that the vacuum tubes have sufficient power capacity, *i. e.*, sufficient filament emission and normal filament brilliancy. The type UV-201-A and C-301-A tubes, when new and used with a 90-volt B battery, have sufficient emission and, therefore, power capacity, to permit faithful reproduction at only very moderate intensity. However, when the volume is increased with this combination, an accentuation of harmonics occurs, which are evidenced in a faithful speaker by nasal or rattling tones. An unfaithful reproducer will, however,

FIG. 5

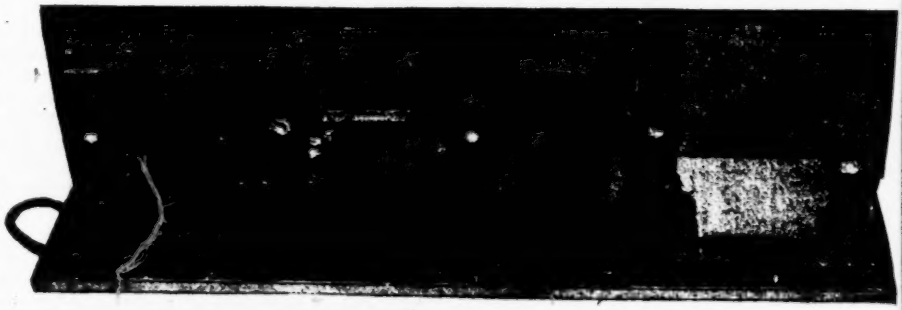
A large cone speaker built in experimental form. Its mechanism is not unlike that of the Phonetron shown on the previous page. The cone of this model was about four feet in diameter

smooth these "rough edges" of the sound and give a more pleasing tone; this deceives the listener into believing that the more faithful speaker is faulty, whereas the facts are that the speaker is faithfully reproducing the voice which has been distorted by the vacuum tubes. This condition can be improved by an increase of plate voltage, which will lower the impedance of the tube and affect a greater transfer of the lower frequencies (when used with a transformer of given inductance), and will also permit the increased amplitude of the lower tones to be passed without distortion.

Super-heterodynes and sets of tuned radio frequency type utilizing regeneration have a tendency to change the tonal characteristics of the music or speech, when tuned. R ceiver is tuned to the maximum volume, an a centuation of the bass will be observed. Th may cause all tones to become somewhat drum like in nature with, at times, a complete loss o the treble. The tuning of a receiver should no change the tonal characteristics of the reception excepting that there is, however, a tendency o the human ear to respond more readily to louder sounds. In practically all radio reception of to-day, the magnitude of the treble is greater than the bass. This must not, however, be confused with the accentuation of bass due to regeneration as referred to above, when a partial or complete loss of treble occurs at the tuning point of maximum volume. A good receiver and speaker will reproduce throughout its tuning range the true relative value of bass and treble, the reduced bass on either side of the peak tuning point being due to the failure of the ear to notice the bass until it is sufficiently loud. The intensity of treble will not lessen at the tuning point of maximum volume, but the bass will sound louder.

FIG. 6

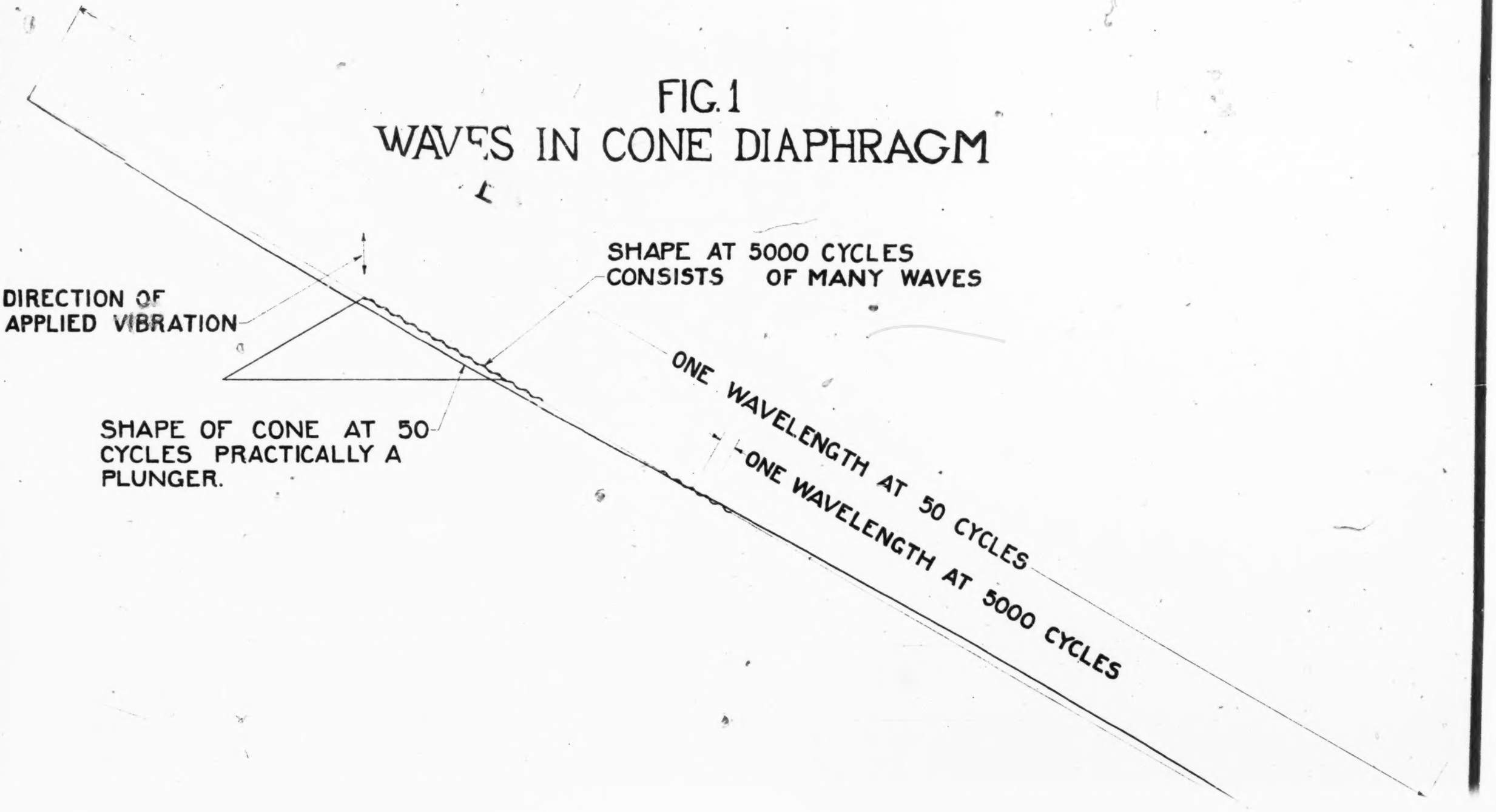
Below is shown another view of the balanced amplifier shown at the top of this page, and schematically in Fig. 2



A FRENCH AMATEUR SHORT WAVE STATION

Owned by *La T. S. F. Moderne*, a Parisian radio magazine. Its call is 8AE and when this station was erected, was using 1764-1499 kc. (180-200 meters). This view shows the antenna and counterpoise

FIG. 1
WAVES IN CONE DIAPHRAGM



CHLADNI FIGURES

AT PLATE

FIG. 2A

EFUL WAVE

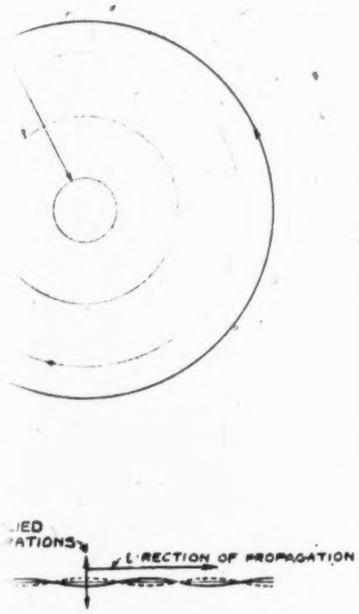


FIG. 2B

ASITIC WAVE

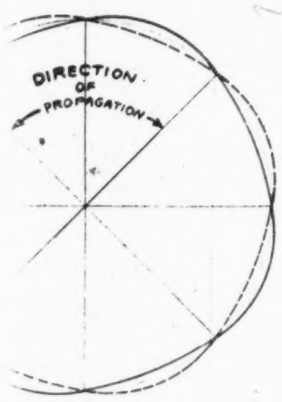
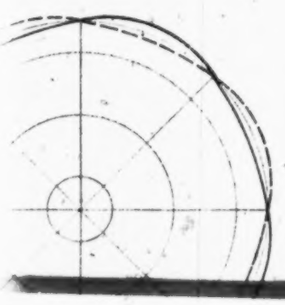


FIG. 2C

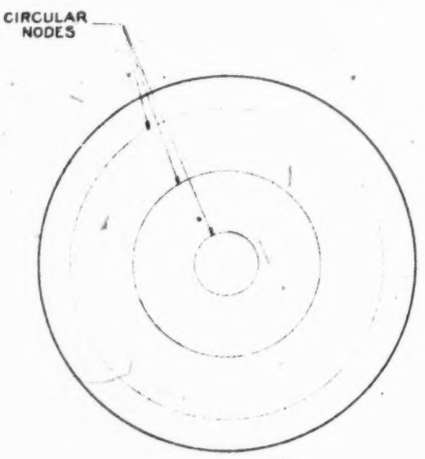
POSITE OF USEFUL AND PARASITIC WAVE



FREE EDGE CONE

FIG. 3A

USEFUL WAVE



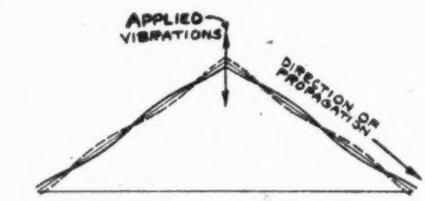


FIG. 3B

PARASITIC WAVE

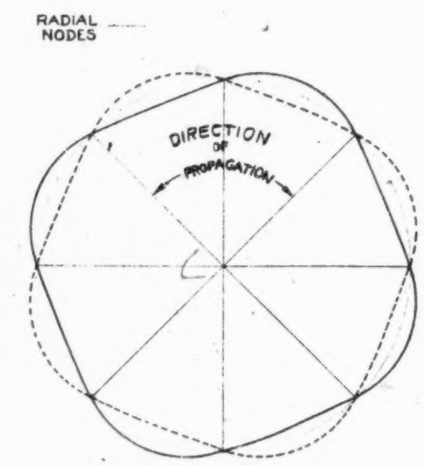
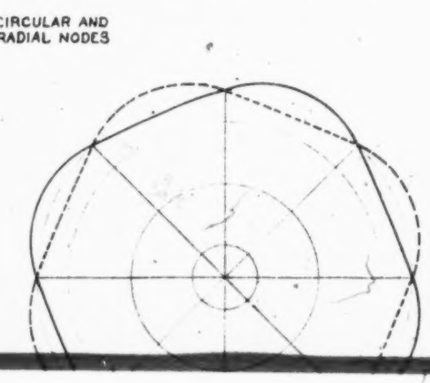


FIG. 3C

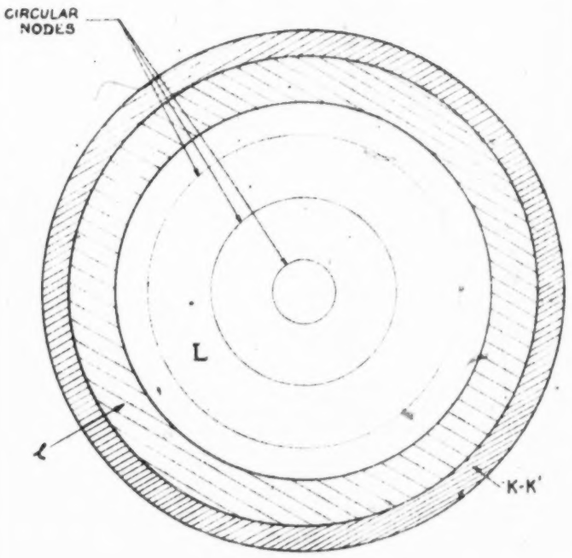
COMPOSITE OF USEFUL WAVE AND PARASITIC WAVE



HOPKINS CONE

FIG. 4A

USEFUL WAVE



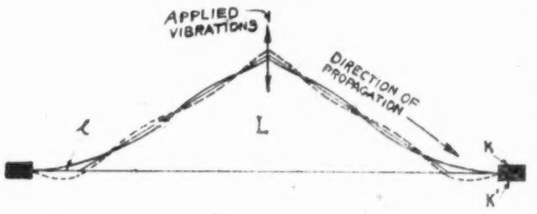


FIG. 4B

PARASITIC WAVE RESTRICTED

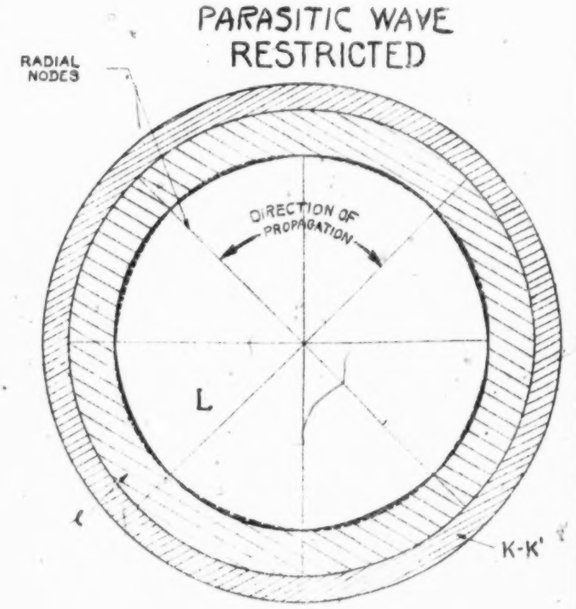


FIG. 4C

COMPOSITE OF USEFUL WAVE WITH PARASITIC WAVE RESTRICTED

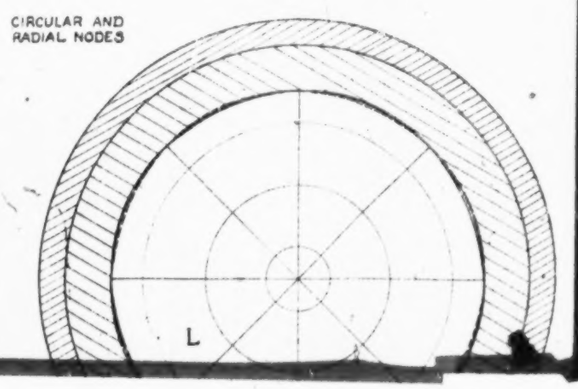


FIG. 2A

USEFUL WAVE

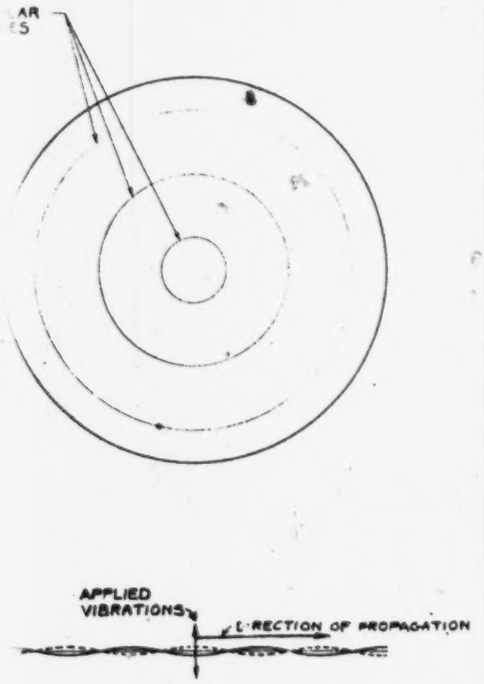


FIG. 2B

PARASITIC WAVE

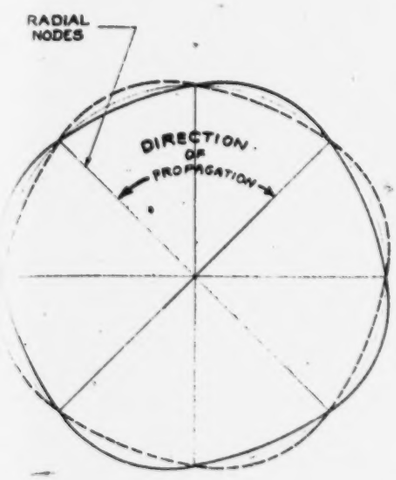


FIG. 2C

COMPOSITE OF USEFUL WAVE AND PARASITIC WAVE

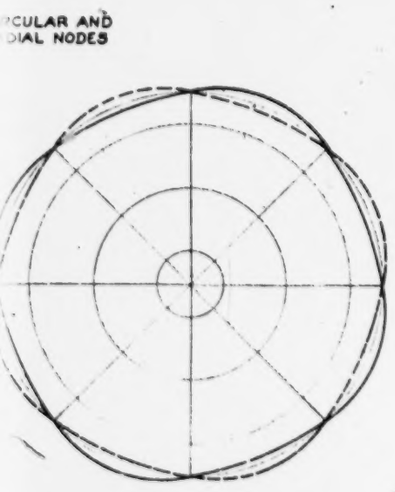


FIG. 3A

USEFUL WAVE

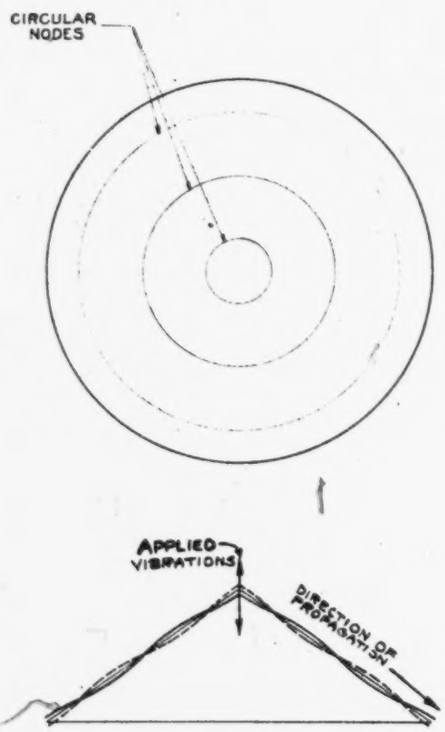


FIG. 3B

PARASITIC WAVE

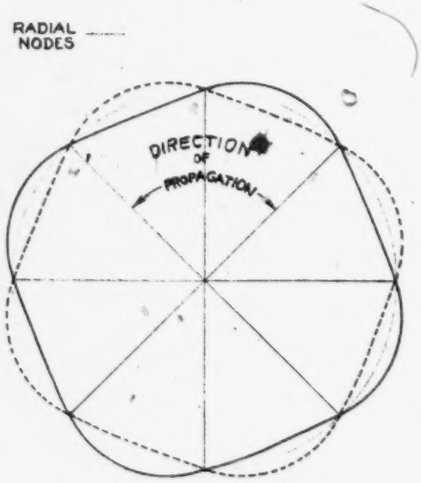


FIG. 3C

COMPOSITE OF USEFUL WAVE AND PARASITIC WAVE

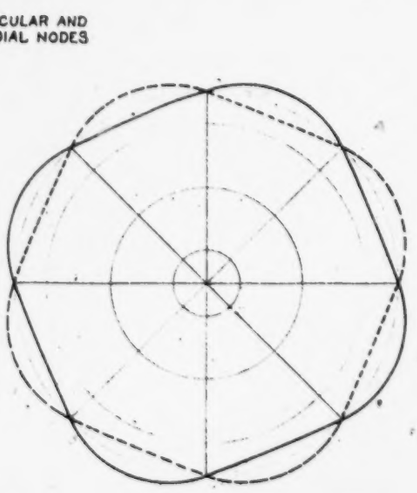


FIG. 4A

USEFUL WAVE

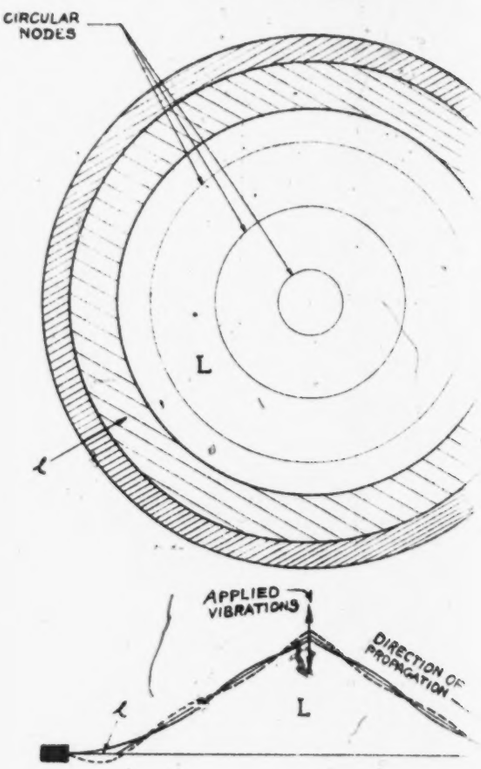


FIG. 4B

PARASITIC WAVE RESTRICTED

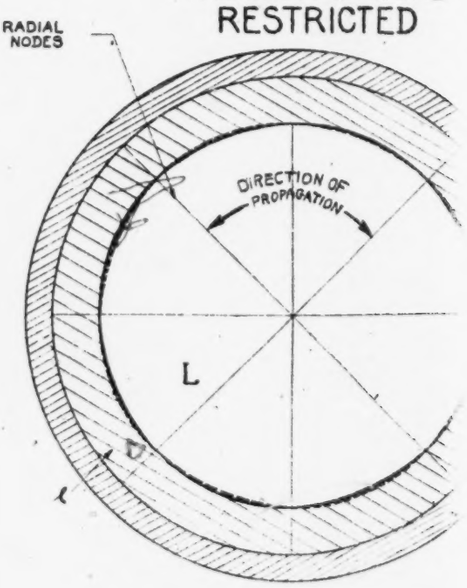
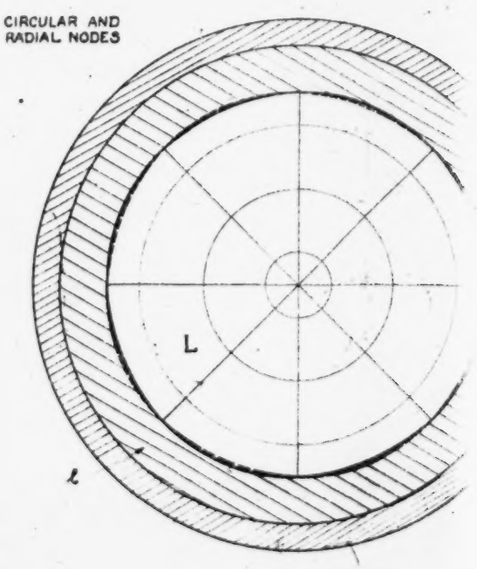


FIG. 4C

COMPOSITE OF USEFUL W/ WITH PARASITIC WAVE REST



Methods of High Quality Recording and Reproducing of Music and Speech based on Telephone Research

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Synopsis.—The paper deals with an analysis of the general requirements of recording and reproducing sound, with the nature of the inherent limitations where mechanical records are used, and a detailed description of a solution involving, first, the use of electrical equipment for the purposes of recording and, second, the use of mechanical equipment based on electric transmission methods for reproducing.

Probably the most useful feature of the paper is the complete description of the application of electrical transmission theory to mechanical transmission systems. A detailed analysis is made of the analogies between the electrical and the mechanical systems.

Introduction

THE problem with which this paper is concerned, in its broadest sense, may be stated as that of taking sound from the air, storing it in some permanent way and reproducing it again without appreciable distortion. It is immaterial from the general standpoint whether the means used are mechanical or electrical or a combination of the two. The choice of which method to use will depend largely upon the commercial requirements accompanying the specific purpose for which the reproduction is being made. For instance, it is quite probable that the means chosen for reproduction in residences would differ materially from those used in large ballrooms or in the presentation of synchronized motion pictures.

Before considering the methods and results referred to in the title of this paper, it may be well to make a rough division of the problem. The storing or recording of sound requires, first, a mechanical system which will respond faithfully to the sound waves which are to be recorded. Then, there is required some material in or on which this sound may be recorded and an intervening system which permits the sound waves to make the record in this material. In the usual case, and in that with which we are particularly concerned here, there is a mechanical system which will vibrate in response to the sound which is to be recorded and

1. Both members of the technical staff, Bell Telephone Laboratories.

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directly through some mechanical linkage or less directly through an electrical linkage, drive a cutting mechanism which will impress a wax record.

The first consideration, therefore, is the character of the sound which is to be recorded including all of the effects of reverberation and the general questions of studio design. Next to be considered is the manner in which the cutting instrument shall impress this speech or musical record upon the constantly rotating wax disk, which disk is commonly called the wax master. In this connection, there will be discussed also the relative value of the electrical and mechanical linking of the cutting knife with the mechanism which receives the sound waves. Following the discussion of these problems and a brief reference to the state of the prior art, there remains to be considered the reproduction of the sound which is stored in the cuts or grooves of the wax record.

In the case of reproduction also, there is required a mechanical system which will respond to these cuts in the wax and a system which will set up in the air-sound waves essentially identical to those picked up by the first mechanism of the recording system. Between these two systems, a mechanical linkage intervenes in the case under discussion, but reference is made to the relative advantages of this system compared with the use of an electrical linkage.

First to be described, is the character of the sound which is to be recorded and reproduced and the effects of reverberation and transients upon the listener's sensation of this sound.

Studio Characteristics and Transients

Phonographic reproduction may be termed perfect when the components of the reproduced sound reaching the ears of the actual listener have the same relative intensity and phase relation as the sound reaching the ears of an imaginary listener to the original performance would have had. Obviously, it is very difficult, if not impossible, to fulfill all of these requirements with a single channel system, that is, with a system which does not have a separate path from each ear of the listener to the sound source.

The use of two ears, that is, two-channel listening, gives the listener a sense of direction for each of the various sources of sound to which at a given moment he may be listening, and, therefore, he apprehends them in their relative distribution in space. It has been found possible with a single channel system, however, by controlling the acoustic properties of the room in which the sound is being recorded, to simulate to a considerable degree in the reproduced music the effective space relationships of the original. In this case, with a one-channel system, the directional effect is, of course, entirely absent, and the spatial relationship which is apprehended is probably due to the increased apparent reverberation of the instruments situated at the far end of the room as compared with those in the near foreground.

In recording work, therefore, one of the important acoustic characteristics of a room is its time of reverberation. Although it is probable that this is the most comprehensive single factor, experiment has shown that the shape of the room and the distribution and character of the damping surfaces play a part in the excellence of music in such a room.

It has been shown by Sabine[2] that for piano music, studios should have a time of reverberation measured by his method of 1.08 seconds. Experience has indicated that this figure is also very closely correct for other types of music. This figure of Sabine's assumes binaural listening. With single-channel systems, such as most of the present reproduction systems, whether for radio or the phonograph, the ability of the listener to separate the reverberation from the direct music by means of the sense of direction is completely removed and there is thrust upon his attention an apparently excessive amount of room echo. Experiment has shown that a time of reverberation for the recording room ranging from slightly more than ½ to slightly less than ¾ of Sabine's figure affords in the reproduced music the effect of a room with proper acoustics. When this effect is accomplished, the person listening to the reproduced music has the consciousness of the music being played in a continuation of the same room in which he is listening and also has a sense of spatial depth.

Experiment has indicated further that any transients set up by the recording or reproducing system constitute a second cause of apparent increased reverberation. The data obtained thus far are insufficient to permit assignment of quantitative values to the importance of these two factors.

At the present state of the art, the most important requirement of a recording or reproducing system is its frequency characteristic. This involves two factors—intensity versus frequency, and phase distortion versus frequency. The effect of the second of these factors is not thoroughly understood but as it is closely related to the production of transients it has to be considered, as mentioned above. The system to be described is, however, relatively free from violent phase shifts within most of the range covered, but does have some undesirable phase-shift characteristics with small accompanying transients near its limiting cut-off frequencies.

Frequency Requirements

The frequency range which it would be desirable to cover if, it were possible, with relatively uniform intensity for the transmission of speech and all types of music including pipe organ is from about 16 cycles per second to approximately 10,000.

2. Collected papers of W. Sabine.

It may be interesting to examine the record requirements for a band of frequencies this great. For the purpose of this illustration, a lateral cut record will be assumed although in all the factors except the time which the record will run. the arguments apply in a similar manner to the hill-and-dale cut. Since, for mechanical reproduction, the sound at a given pitch is radiated by means of a fixed radiation resistance, it is necessary that the record must be cut with a device the square of whose velocity is proportional to the sound power. Under these conditions, it is seen that for a given intensity of sound the amplitude is inversely proportional to the frequency of the tone, and that a point will be reached somewhere at the low end of the sound spectrum where this amplitude will be great enough to cut from one groove into the adjacent groove, or in case of vertical cut, to cut so deeply that with present materials the wax will tear instead of cut away with a clean surface. This means that there is an inherent maximum amplitude beyond which it is not commercially feasible to go. Similarly the minimum radius of curvature of sine waves of various frequencies cut at constant velocity is inversely proportional to the frequency, so that as higher and higher frequencies are reached the radius of curvature becomes smaller and smaller until finally it becomes too small for the reproducing needle to follow. There is, therefore, an inherent limit at the upper end.

In order to extend these limits, it is necessary in the case of the low end to make the spiral coarser and in the case of the high end to run the record at a higher speed. Both of these changes tend to decrease the time which a record of a given size can be made to play. The only alternative of these methods is to cut the record less loud than is the present standard practise and make the reproducing equipment more sensitive. This could easily be done if it were not for the "record noise" or "surface noise," as it is commonly called. Since this surface noise is already loud enough in comparison with the reproduced music to be somewhat objectionable, no appreciable gain in this direction can be made until the technique of record manufacture has been distinctly improved.

In this connection, there is one other interesting point. It has been suggested that if electric reproduction were used, it would be possible to cut the record with a characteristic other than uniform velocity sensitiveness and correct for the error by an electrical system whose characteristic is the inverse of the characteristic of record. If the change which is made in the recording characteristic tends toward cutting at uniform acceleration sensitiveness, the amplitude varies inversely as the square of the frequency and hence the difficulties at the low end of the scale are greatly enhanced. Similarly, if the records are cut more nearly at constant amplitude, the radius of curvature of the sine waves decreases as the square of the frequency, hence the difficulties are placed at the upper end. In the process which is being described in this paper, these limitations have been met commercially by having a frequency characteristic of the uniform velocity type between the frequencies of 200 and approximately 4000 cycles per second. Below 200 it has been necessary to operate at approximately constant amplitude with a resulting loss in intensity which loss increases as the frequency decreases. Above 4000 it has been necessary to operate at approximately constant acceleration with its consequent slight loss in intensity at the very high overtones. With a characteristic of this type, a range of frequencies from 60 cycles to 6000 can be recorded with reasonable success although the very low and very high range are slightly deficient. (See Fig. 14) With a record having such a frequency characteristic, the inherent limitations are divided between the two ends of the frequency band and where electrical reproduction methods are used, it is possible to employ a reproduction system whose frequency characteristic compensates for that of the record.

It should be pointed out that an attempt to record notes lower than the low cutoff of the above mentioned apparatus would result in recording only those harmonics of the notes which lie above the cut-off. This in no way prevents the listener from hearing the notes, reproduced by means of the harmonics only, as notes with the pitches of the missing fundamentals although it does somewhat change the quality of the tone.[3] If it were not for this ability of the ear to add the fundamental pitch of a note, of which only the harmonics are being reproduced, most of the older phonographs and loud speakers would have been totally useless for the reproduction of speech and music.

Mechanical Versus Electrical Recording

In attacking the recording part of the problem, two ways at once present themselves; first, the direct use of the power, of the sound being recorded, to operate the recording instrument; and second, the use of high quality electric apparatus with vacuum tube amplifiers in order to give more freedom to the artists and better control to the process. The amount of power available to operate the recorder directly from the sound in the recording room is so small as to make it extremely difficult to make records under natural conditions of speaking, singing, or instrumental playing. As the use of high quality electric apparatus with associated amplifiers has a very distinct advantage over the acoustic method, they have been adopted for the recording part of the process. Fig. 1A shows a picture of a group of artists recording by means of the sound power directly, while Fig. 1B shows a record being made by the same artists with the electric process.

3. Physical Criterion for Determining the Pitch of a Musical Tone, H. Fletcher, *Phys. Rev.*, Vol. 23, No. 3, March, 1924.

It will be noticed in Fig. 1A that the artists are grouped very closely about the horn. In the case of the weaker instruments such as violins, it has been possible to use only two of standard construction. The rest of the violins are of the type known as the "Stroh" violin which is a device strung in the manner of a violin but so arranged that the bridge vibrates a

FIG. 1A -PICTURE OF AN ORCHESTRA RECORDING FOR THE ACOUSTIC PROCESS. THIS PICTURE WAS FURNISHED THROUGH THE COURTESY OF THE VICTOR TALKING MACHINE COMPANY, CAMDEN, NEW JERSEY

diaphragm attached to a horn. This horn is directed toward the recording horn, as shown by the player in the foregound.

With such an arrangement of musicians, it is very difficult to arouse the spontaneous enthusiasm which is necessary for the production of really artistic music.

FIG. 1B PICTURE OF THE SAME ORCHESTRA SHOWN IN FIG. 1A, BUT RECORDING FOR THE ELECTRIC PROCESS. THIS PICTURE WAS FURNISHED THROUGH THE COURTESY OF THE VICTOR TALKING MACHINE COMPANY, CAMDEN, NEW JERSEY

In Fig. 1B the musicians are sitting at ease more nearly in their usual arrangement and all are using the instruments which they would use were they playing at a concert. Furthermore, the microphone is now sufficiently far away from the orchestra to receive the sound in much the manner that the ears of a listener in the audience would receive it. In other words, it picks up the sound after it has been properly blended with the reflections from the walls of the room. It is in this way that the so-called "atmosphere" or "room-tone" has been obtained.

In the old process, it sometimes happened that after the instruments had been arranged in such a manner that the relative loudness of the various part had been balanced correctly, it was found that the whole selection was either too loud or too weak. This usually meant a complete rearrangement of the players. With the flexibility introduced by the use of electrical apparatus including amplifiers, the control of loudness is obtained by simple manipulation of the amplifier system and is in no way related to the difficulties of the relative loudness of one instrument to another. The only problem for the studio director in this case is to obtain the proper balance among the various musical instruments and artists. The advantages derived from this added ease of control are also made manifest in that it is much easier and less tiresome for the artists and it is usually possible to make more records in a given time.

MECHANICAL VERSUS ELECTRICAL REPRODUCING

Where the question of reproduction is concerned, the same two alternatives mentioned for recording present themselves, namely, direct use of power derived from the record itself versus the use of electromechanical equipment with an amplifier. In this case, however, the situation is a little different as the power which can be drawn directly from the record is more than sufficient for home use. Since any method of reproducing from mechanical records by electrical means involves the use of a mechanical device for transforming from mechanical to electrical power and a second such device for transforming from electrical back to mechanical power, that is, sound, it is necessary to use two mechanical systems, one at each end of an electrical system. Where the power which can be supplied by the record, is sufficient to produce the necessary sound intensity, as in the case of home use, it is in general simpler to design one single mechanical transmission system than it is to add the unnecessary complications of amplifiers, power supply and associated circuits. In cases where music is to be reproduced in large auditoriums, the power which can be drawn from the record may be insufficient and some form of electric reproduction using amplifiers becomes necessary.

BRIEF DESCRIPTION OF RECORDING SYSTEM

The system used for recording consists of a condenser transmitter, a high quality vacuum tube amplifier and an electromagnetic recorder. Fig. 2 shows the calibration of the condenser transmitter and the associated amplifiers. The condenser transmitter and amplifiers are so designed that the current delivered to the recorder circuit is essentially proportional to the sound pressure at the transmitter diaphragm. The electromagnetic recorder, which will be described later, is designed to work with this type of system.

With the exception of this electromagnetic recorder, apparatus of this type has already been described in the literature.[4] In addition to this equipment which might be called the recording amplifier system, there is a volume indicator for measuring the power which is being delivered to the recorder and also an audible monitoring system. The audible monitoring system consists of an amplifier whose input impedance is high compared with the recorder impedance and a suitable loud speaking receiver. The monitoring amplifier is bridged directly across the recorder and operates the loud speaking receiver so that the operator may listen to the record as it is being made.

In the design of the recording and reproducing systems each part of the system has been made as nearly perfect as possible. Errors of one part have not been designed to compensate for inverse errors in another part. Although this method is the more difficult, its flexibility, particularly as regards the commercial possibilities of future improvements justifies the extra effort.[5] There is, therefore, no distortion in the record whose purpose is to compensate for errors in the reproducing equipment; the only intended distortion in the record being that required by the inherent limitations mentioned above. See Figs. 2, 14 and 20.

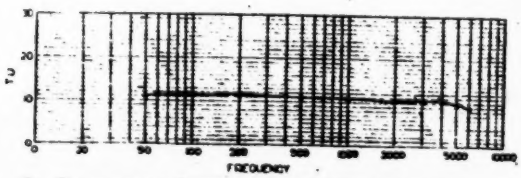


FIG. 2—CALIBRATION OF THE CONDENSER TRANSMITTER AND ASSOCIATED AMPLIFIERS

This curve shows merely the relative frequency sensitiveness of the system, the zero line having been chosen arbitrarily

GENERAL BASIS OF DESIGN

An interesting feature of the development of the mechanical and electromechanical portions of the recording and reproducing system is their quantitative design as mechanical analogs of electric circuits. Both the recording and reproducing systems are good examples of the use of this type of analogy.

The economic need for the solution of many of the problems connected with electric wave transmission over long distances coupled with the consequent development of accurate electric measuring apparatus has led to a rather complete theoretical and practical knowledge of electrical wave transmission. The advance has been so great that the knowledge of electric systems has surpassed our previous engineering knowledge of mechanical wave transmission systems. The result is, therefore, that mechanical transmission systems can be designed more successfully if they are viewed as analogs of electric circuits.

While there are mechanical analogs for nearly every form of electrical circuit imaginable, there is one particular class of electrical circuits whose study has led to ideas of the utmost value in guiding the course of the present development. This class of circuits consists of infinitely repeated similar sections of one or more lumped capacity and inductance elements in series and shunt and are commonly known as filters. The study of filters began with the work of Campbell[6] and a recognition of their importance as frequency selective systems in telephone repeaters, carrier systems, radio, signalling systems, etc., led to their intensive study. In the available literature is to be found a fairly complete statement of their properties and details of their design.[6]

It will be recalled in the case of the telephone circuit that the introduction of inductance coils at regular intervals in the circuit produced a remarkable change in the transmission characteristic. Over a broad band of frequencies the attenuation was reduced and made fairly uniform over that range while beyond a critical frequency called the cut-off frequency the attenuation became very high. In the ideal filters with zero dissipation the transmission characteristics are of the same nature but more clear cut. Structures of this type with infinitely repeated sections will have one or more transmission bands of zero attenuation and one or more bands having infinite attenuation. The impedance characteristics of such a structure measured from certain characteristic points will be pure resistance more or less uniform in the transmission bands, and pure reactance in the attenuation bands. These terminations are

4. Wente, E. C., "Condenser Transmitter as a Uniformly Sensitive Instrument for Measuring Sound Intensity," *Phys. Rev.*, Vol. 10, 1917.

Crandall, I. B., "Air-Damped Vibrating Systems," *Phys. Rev.*, Vol. 11, 1918.

Wente, E. C., "Electrostatic Transmitter," *Phys. Rev.*, Vol. 19, 1922.

Martin, W. H. and Fletcher, H., "High Quality Transmission and Reproduction of Speech and Music," TRANS. A. I. E. E., Vol. 43, 1924, p. 384.

Green, I. W. and Maxfield, J. P., "Public Address Systems," TRANS. A. I. E. E., Vol. 43, 1923, p. 64.

5. Green, I. W. and Maxfield, J. P., "Public Address Systems," TRANS. A. I. E. E., Vol. 42, 1923, p. 64.

6. Campbell, G. A., "On Loaded Lines in Telephonic Transmission," *Phil. Mag.*, March 1903.

Campbell, G. A., U. S. Patents 1,227,113; 1,227,114; "Physical Theory of the Electric Wave Filter," *Bell System Technical Journal*, November 1922.

Zobel, O. J., "Theory and Design of Uniform and Composite Electric Wave Filters," *Bell System Technical Journal*, January 1923.

Peters, L. J., "Theory of Electric Wave Filters Built up of Coupled Circuit Elements," TRANS. A. I. E. E., May 1923.

Carson, J. R. and Zobel, O. J., "Transient Oscillations in Electric Wave Filters," *Bell System Technical Journal*, July 1923.

Zobel, O. J., "Transmission Characteristics of Electric Wave Filters," *Bell System Technical Journal*, October 1924.

Johnson, K. S., and Shea, T. E., "Mutual Inductance in Wave Filters with an Introduction on Filter Design," *Bell System Technical Journal*, January 1925.

Johnson, K. S., "Transmission Circuits for Telephonic Communication," D. Van Nostrand, 1925.

mid-series; that is, the entering element being a series one of half the normal series element; or mid-shunt; that is, the entering element being twice the impedance of the normal shunt element. The corresponding impedances are called the mid-series and mid-shunt characteristic or iterative impedances.

If we retain the first few sections of such a structure

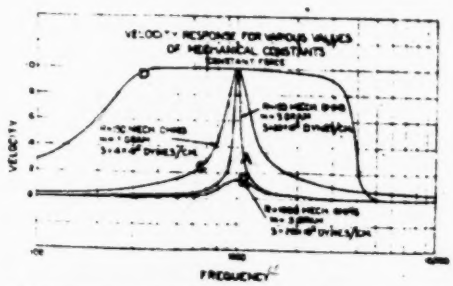


FIG. 9 - VELOCITY RESPONSE FOR VARIOUS VALUES OF MECHANICAL CONSTANTS

and terminate them with a resistance which is equal to the resistance impedance of the infinite line from which they were taken, the characteristics are substantially unchanged. It is understood, of course, that this resistance equals approximately the resistance impedance of the remainder of the infinite line at most of the frequencies in the transmission band in which we are interested.

The presence of small amounts of damping in the various elements also has but slight effect on the general characteristics. These results could in general be readily applied to the various telephone transmission problems because the source and load between which the filter system was inserted generally had or could be made to have a nearly resistance impedance equalling the mid-series or mid-shunt impedance of the filter within the transmission band. The filter and terminating impedances may then be said to be matched. Where adjacent sections in the filter have impedances similar in character but different in absolute magnitude they may be joined by a suitable transformer.

Many early attempts were made to design mechanical transmission systems having a wide frequency range in which highly damped single or multi-resonant systems were employed. In these attempts both of the obvious methods of increasing the damping were used, namely, that of adding a resistance to the system and that of increasing the value of the compliance and decreasing mass in such proportion as to maintain the same natural frequency. The former of these methods reduces the sensitivity of the system at the point where it is most efficient, (See Fig. 9), while the second method increases the response at the points where the system is less sensitive, namely, away from its resonance point. Fig. 9 shows four curves—first, a singly resonant system, Curve *A*; second, the same system with friction added, Curve *B*; third, the same system without the added friction but with an increase in compliance and a decrease in mass such that the natural period remains the same; Curve *C*, and fourth, a band pass type of circuit whose resistance impedance is the same as that of the system shown in Curve *A*. (See Curve *D*.)

The results of filter theory have shown how these resonances should be coordinated so that when a proper resistance termination is used high efficiency and equal sensitivity are obtained over a definite band of frequencies by elimination of response to all frequencies outside the band. With the electrical case of a repeated filter, each section considered by itself resonates at the same frequency but when combined into a short-circuited filter of n sections, there will be n natural frequencies. However, when such a system is terminated with a resistance which equals the nominal characteristic impedance in the transmission band, uniform response in the terminating resistance is obtained over the entire band.

DETAILED ANALYSIS OF MECHANICAL AND ELECTRICAL ANALOGS[7]

Before going on with a detailed treatment of the electrical analogues of the mechanical structures used in the problem of phonographic reproduction, a list of the corresponding quantities used in the two systems will be given, together with the symbols employed.

Mechanical		Electrical	
Force	= F (dynes)	Voltage	= E (volts)
Velocity	= v (cm. sec.)	Current	= i (amperes)
Displacement	= s (cm.)	Charge	= q (coulombs)
Impedance	= z (dyne sec. cm. or mechanical ohms)	Impedance	= Z (ohms)
Resistance	= r (dyne sec., cm.)	Resistance	= R (ohms)
Reactance	= x (dyne sec./cm.)	Reactance	= X (ohms)
Mass	= m (gms)	Inductance	= L (henries)
Compliance	= c (cm. dyne)[8]	Capacity	= C (farads)

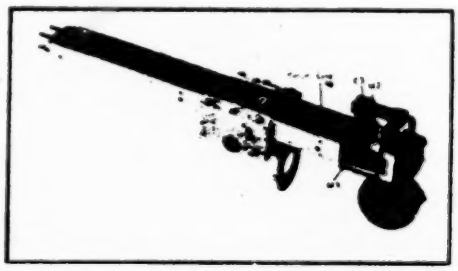


FIG. 10—THIS FIGURE SHOWS AN ELECTROMAGNETIC RECORDER COMPLETE EXCEPT FOR THE BOTTOM OF THE CASE

7. The authors wish to express their appreciation to Mr. E. L. Norton for his courtesy in working out the mathematics of the mechanical and electrical analogs which are shown in this paper.

8. H. W. Nichols, "Theory of Variable Dynamical Electrical Systems," *Phys. Rev.* Vol. 10, 1917.

General Design of Mechanical Systems

In designing mechanical systems of the band pass type, the problem is three fold—first, that of arranging the masses and compliances such that they form repeated filter sections; second, determining the magnitude of these quantities so that with or without transformers the separate sections all have the same cut-off.

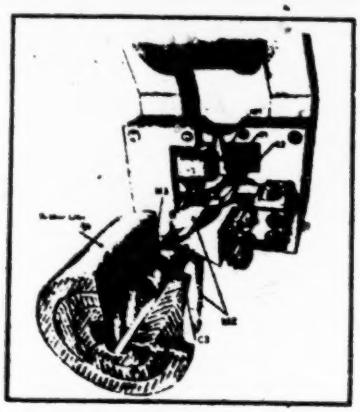


Fig. 11—Detailed Drawing of the Mechanical Filter of an Electromagnetic Recorder. (Lettering Same as in Fig. 12)

frequencies* and characteristic impedances; third, to provide the proper resistance termination. Where the transmitted mechanical power has not been radiated

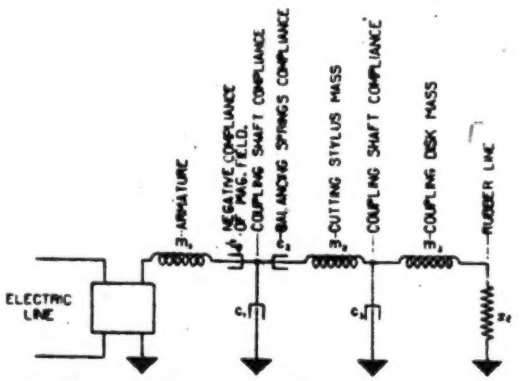


Fig. 12—Equivalent Electric Circuit of the Electromagnetic Recorder

as sound this third part has been one of the most difficult to fulfill.

In designing these systems, practical difficulties arose—first, the difficulty of insuring that the parts vibrated in the desired degrees of freedom only, and second, the difficulty of determining the magnitudes of the various effective masses, compliances and resistances. Before the work to be described could be carried out practically it became necessary to develop a method of measuring mechanical impedances[10]. This method of measurement has been very useful not only in determining the magnitudes of the impedances in the degrees of freedom in which it is desired that they shall operate, but in determining the impedances to motion of the various parts in directions in which they should not be permitted to vibrate. In connection with the measurement of the magnitudes of the parts in the desired degrees of freedom this method enables us to determine the constants of the mechanical networks under their conditions of operation. Experience so far has indicated that when all the degrees of freedom have been taken into account and when the dynamic axes of vibration have been properly chosen, the static and dynamic constants of the parts are the same, and it is then possible to check the parts by simple static measurements. In the early attempts to build these systems very large discrepancies between the static and dynamic characteristics were found.

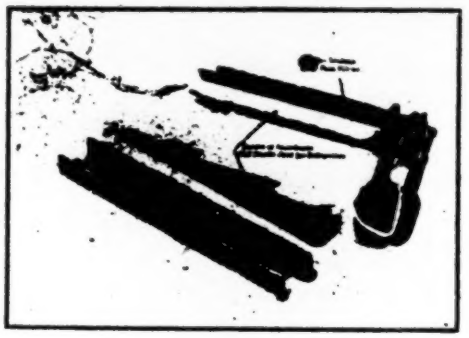


Fig. 13—Electromagnetic Recorder using Lumped Loaded Termination

The method of furnishing dissipation to the lumped loaded line is shown

The Recorder

One of the early practical phonographic applications of electric filter design to mechanical problems was the development of an electromagnetic recorder. The instrument as finally constructed is essentially a properly terminated three-section mechanical filter in which the recording stylus and its holder constitute the series mass in the second section. Since a filter of this type appears at its input end as approximately a pure resistance within the transmission band, the current in the series inductances, that is, in the mechanical

*It is of course permissible to have a section having a higher cut-off than the others provided its characteristic impedance is the same as that of the others over the transmission band of those having the lower cut-off.

10. Kennelly, A. E. and Affel, H. A., "The Mechanics of Telephone Receiver Diaphragms, as Derived from their Motional Impedance Circles," *Proc.* A. A. A. S., Vol. 51, No. 8, November, 1915.

Kennelly, A. E. and Pierce, G. W., "The Impedance of Telephone Receivers as Affected by the Motion of their Diaphragms," *Proc.* A. A. A. S., Vol. 48, No. 6, September, 1912.

case, the velocity of the series masses is proportional to the driving force.

Figs. 10, 11 and 12 show respectively, a complete recorder, a drawing of the mechanical filter of such a recorder and a diagram of the equivalent electric circuit.

Referring to Figures 11 and 12, all of the equivalents can readily be seen with the exception of the terminating resistance and the negative compliance, c_n. The reason for using the type of termination shown lies in the fact that most of the known mechanical resistances have values which are functions of frequency or of amplitude or of both. Also in most cases, the mechanical resistance is accompanied by either a mass or compliance reactance. By using a continuous transmission line (shown completely in Fig. 10 and partially in Fig. 11) which line is sufficiently long so that a wave entering it will be essentially absorbed before it has reached the far end, been reflected and returned to the entering end, it has been possible to use imperfect types of damping for this line and still

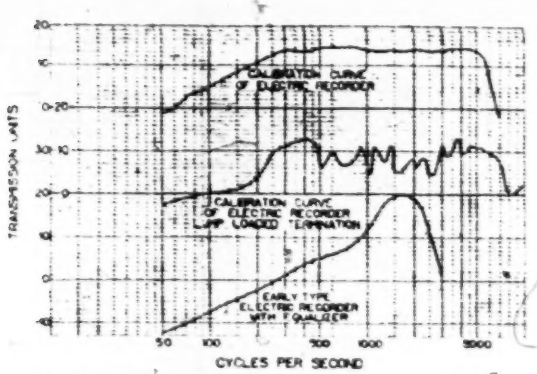


Fig. 14—Calibration Curve of Three Types of Electromagnetic Recorders

obtain over the desired band, an essentially pure resistance at the input end.

Fig. 14 shows calibration curves of three types of recorders. The bottom curve shows an early type of highly damped singly resonant system. The middle curve is a calibration of a low pass mechanical filter type using lumped loading in the resistance line.* The upper curve shows the calibration of the recorder shown in Fig. 10.

The compliance $-c_0$ is a mechanical quantity for which there is no simple electric analog. In a balanced armature type of structure such as that shown in Fig. 11, the action of the field on the armature, when it is at its center point, is balanced. If, however, the armature be deflected, a small distance from this equilibrium, there is exerted by the magnetic field a torque tending to pull the armature further away from its center position. The value of this torque for small amplitudes is proportional to the angular displacement. It is therefore seen that this quantity is of the nature of a compliance but that the back force is in a reverse direction to that required for a positive compliance.

*For a description of this, see the complete paper available in pamphlet form upon request.

Design of the Reproducing Apparatus

As the analogy between the mechanical and electrical filter is more perfectly shown in the case of the reproducing equipment, the detailed quantitative descrip-

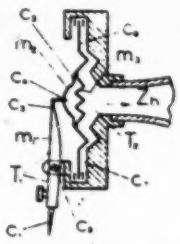


Fig. 15—Diagrammatic Sketch of the Mechanical System of the Phonograph

tion will be given in this connection.* Figs. 15 and 16 show respectively a diagram of the reproducing system and its equivalent electric circuit. From these diagrams it is evident which units in the mechanical system correspond to the various electrical parts. As the series compliances c_3, c_1 and c_4 have been made so large that the low frequency cut-off caused by them lies well below the low frequency cut-off of the horn, an inappreciable error is introduced in using for design

Fig. 16—Electric Equivalent of the System Shown in Fig. 15

purposes formulas of low pass filters[11]. The two formulas which will be used are as follows:

$$f_c = \frac{1}{\pi}\sqrt{\frac{1}{mc}} \qquad (12)$$

Where

f_c = cut-off frequency of a lumped transmission system in cycles per second

11. Campbell, G. A., "On loaded lines in Telephonic Transmission," *Phil. Mag.*, March, 1903.

c = shunt compliance per section in centimeters per dynes

m = series mass per section in grams

$$z_0 = \sqrt{\frac{m}{c}} \quad (13)$$

Where z_0[12] is the value of characteristic impedance over the greater part of the band range.

Equations (12) and (13) which form the basis of the design work contain four variables, f_c, c, m and z_0. It is, therefore, necessary to determine two of them by the physical requirements of the problem after which the other two are determined. The upper cut-off frequency f_c was arbitrarily chosen at 5000 pps. as a compromise between the highest frequency occurring on the record and the increase in surface noise as the cut-off is raised. The choice of the other arbitrarily set variable came after considerable preliminary experimenting and was fixed by the difficulty of obtaining a diaphragm which is light enough and has a large enough area. Hence the effective mass of the diaphragm m_3, (Figs. 15-16) was fixed at 0.186 grams which value can be obtained by careful design. The effective area can be made as large as 13 square centimeters. For convenience let the arbitrary value chosen for $f_c = \bar{f}_c$ and the value of $m = \bar{m}_3$.

Solving Equations (12) and (13) for c and z_0, we get

$$c = \frac{1}{\pi^2 \bar{f}_c^2 \bar{m}_3} \quad (14)$$

$$z_0 = \pi \bar{f}_c \bar{m}_3 \quad (15)$$

also

$$z_0 = \frac{1}{\pi c \bar{f}_c} \quad (16)$$

In order to obtain the low value of mass mentioned, with a large enough area, it was necessary to make the diaphragm of a very stiff light material. An aluminum alloy sheet 0.0017 in. thick was chosen and concentrically corrugated as shown in Figs. 17 and 18. These corrugations are spaced sufficiently close so that the natural periods of the flat surfaces are all above $\bar{f}_c$. To insure that this central stiffened portion should vibrate with approximate plunger action, which is more efficient than diaphragm action, it is driven at six points near its periphery.

Reference to Figs. 15 and 16 and Equation (14) shows that the compliance of the air chamber c_7, of the spider legs c_5 and shunt tip of the needle arm c_2 are determined. Also the mass of the spider m_2 and the effective mass of the needle arm m_1, as viewed at the point where it is attached to the spider, are determined.

The impedance looking into the system from the record is determined by the rate at which it is necessary to radiate energy in order that the reproduction may be loud enough. The power taken from the record is approximately $v^2 z_0$ since z_0 is a resistance over most of the band. Experiment has shown this value of z_0 to be approximately 4500 mechanical ohms.

But substituting in Equation (13) the value of $\bar{m}_3$, and from Equation (14) the value of c_4, we find that the impedance is only 2920 mechanical ohms. It is, therefore, necessary to use a transformer whose impedance ratio is $\frac{4500}{2920}$. From this and a knowledge of filter structures the needle-point compliance can be determined. The value obtained is easily realized with commercial types of needle.

It will be noted that the record is shown in Fig. 16 as a constant current generator, i. e., a generator whose impedance appears high as viewed from the needle point. That this is necessary is obvious when it is remembered that, if the impedance looking back into the record were to equal the impedance of the filter system, the walls of the record would have to yield an amount comparable with one-half the amplitude of the lateral cut. This would cause a breakdown of the record material with consequent damage.

The design of the system is, therefore, complete except for the resistance termination which is supplied by the horn for all frequencies above its low frequency cut-off. The characteristics of the horn will be dealt with later. The resistance within the band looking in at the small end of the horn is $G A_2$ where G = mechanical ohms per square centimeter of an infinite cylindrical tube of the same area, and A_2 = area in square centimeters of the small end of the horn.

Let A_1 = the effective plunger area of the diaphragm (as previously mentioned this is 13 sq. cm.). The impedance looking back at the diaphragm is

$$z_0 = \pi \bar{f}_c \bar{m}_3 = 2920 \text{ mechanical ohms}$$

from Equation (15), and the impedance looking at a horn whose small end area equals A_2 is

$$z_4 = r_0 = A_2 G \quad (17)$$

Substituting

A_2 = 13 sq. cm.

G = .41 ohms per cm.^{2} we get

$z_4 = r_0$ = 533 mechanical ohms

This is entirely insufficient so that the air-chamber transformer becomes necessary.

To calculate the necessary ratio of areas on the two sides of the air-chamber transformer, the following formula is needed. The formula assumes the chamber to be relatively small compared with all wave lengths of the

12. z_0 may be called nominal mid-shunt or mid-series impedance. Their actual values in the transmission band being at any frequency f,

$$\text{mid-series} = z_0 \sqrt{1 - \left(\frac{f}{f_c}\right)^2}$$

$$\text{mid-shunt} \quad \frac{z_0}{\sqrt{1 - \left(\frac{f}{f_c}\right)^2}}$$

sound to be transmitted, that is, the pressure changes throughout the chamber are substantially in phase.

$$\frac{z_0}{z_h} = \frac{A_1^2}{A_2^2} \tag{16}$$

Where

z_0 = the impedance of the primary side of the transformer in mechanical ohms

z_h = the impedance on the secondary side of the transformer in mechanical ohms, *i. e.*, the horn impedance

Solving this equation with the aid of Equations (15) and (17), we get

$$A_2 = \frac{G A_1^2}{\pi f_c m_c} \tag{22}$$

(A more complete description of this part of the

FIG. 18—SECTIONAL DRAWING SHOWING CONSTRUCTION OF THE SYSTEM SHOWN IN FIG. 17

design is given in the complete paper which will be published in the A. I. E. E. TRANSACTIONS for 1926.)

The horn which has been used as a terminating resistance to the mechanical filter structure is a logarithmic one. The general properties of logarithmic horns have been understood for some time.[13]

There are two fundamental constants of such a horn—the first is the area of the large end and the second the rate of taper. The area of the mouth determines the lowest frequency which is radiated satisfactorily. The energy of the frequencies below this is largely reflected if it is permitted to reach the mouth.

From the equations given by Webster,[13] it can be shown that all logarithmic horns have a low frequency cut-off which is determined by the rate of taper. If the rate of taper is so proportioned that its resulting cut-off prevents the lower frequencies from reaching the horn mouth, the horn will then radiate all frequencies reaching its mouth and very little reflection will result.[14] It is, therefore, possible to build a horn having no marked fundamental resonance.

Since the characteristics of [illegible] determined

FIG. 19—SECTIONAL VIEW OF THE FOLDED HORN SHOWING THE AIR PASSAGE

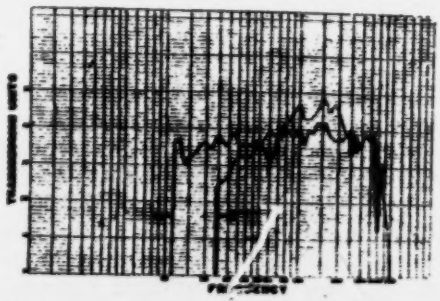


FIG. 20—RESPONSE FREQUENCY CHARACTERISTIC OF TWO PHONOGRAPHS. CURVE *A* SHOWS THE CHARACTERISTIC OF THE BAND PASS FILTER TYPE DESCRIBED. CURVE *B* SHOWS THE CHARACTERISTIC OF ONE OF THE BEST COMMERCIAL MACHINES PREVIOUSLY ON THE MARKET

by the area of its mouth and by its rate of taper the length of the horn is determined by the area of the small end. This area is determined in turn by the mechanical impedance and effective area of the system

13. Webster, A. G., "Acoustical Impedance and Theory of Horns and Phonograph," *Proc.* Nat. Acad. of Sci., 1919.

14. The authors wish to express their appreciation in this connection of the work of Mr. P. B. Flanders who carried out the mathematical investigation of these relationships and to Mr. A. L. Thuras who checked experimentally the mathematical theory.

which it is terminating, as shown in Equation (22). It is seen, therefore, that the length of the horn should not be considered as a fundamental constant. A paper describing the design of horns based on these principles is being prepared.

An interesting feature of the horn which has been built commercially is its method of folding. The sketch in Fig. 19 shows a shadow picture of the horn. It will be noticed that the sound passage is folded only in its thin direction, which permits the radius of the turns to be small and thereby makes the folding compact.

Fig. 20 shows the frequency characteristic of a phonograph designed as shown above with a logarithmic horn whose rate of taper and area of mouth opening place the low cut-off at about 115 cycles. It also shows the characteristics of one of the best of the old style phonographs. Curve *A* represents the new machine, while Curve *B* represents the old style standard machine.

DEFENDANT'S EXHIBIT NO. 11.

473

J. W. MAXWELL.

Mechanical-Telephone.

No. 216,051. Patented June 3, 1879.

Fig. 1.

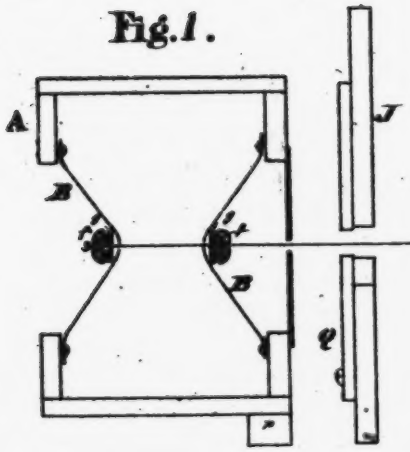
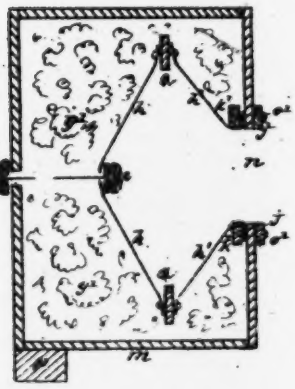


Fig. 2.



Witnesses.

A. M. Stout

F. B. Mott

Inventor,

J. W. Maxwell

UNITED STATES PATENT OFFICE.

JOSEPH W. MAXWELL, OF LOUISVILLE, KENTUCKY.

IMPROVEMENT IN MECHANICAL TELEPHONES.

Specification forming part of Letters Patent No. **216,051**, dated June 3, 1879; application filed November 7, 1878.

To all whom it may concern:

Be it known that I, JOSEPH W. MAXWELL, of the city of Louisville, county of Jefferson, and State of Kentucky, have invented certain improvements in Telephony, of which the following is a specification.

Whereas in an application made by myself for Letters Patent of the United States, filed in the United States Patent Office on the 14th day of October, 1878, for improvement in telephony, I have shown and described an apparatus (among other things) consisting of two sounding-boards and their vibrators, of the same construction and material, placed together apex to apex, apart a few inches only, on the same transmitting-wire, and connected together by another short wire, which extends from the apex of one to the apex of the other, the means of fastening being knots formed on the extremities of the short wire after they had been extended through the vibrators; one apparatus consisting of this combination of parts is placed at each end of a long transmitting-wire, which is passed through the centers of the vibrators, and over and along which vibrations of air or sounds are transmitted from one end of the line to the other, and each apparatus is held to its connection with the wire by a button on each end thereof, and the wire is held taut or otherwise, as the one apparatus may be moved to or from the other.

The sounding-boards may be made of soft pine wood, or any other suitable material, and should have openings in their central portions, over which the vibrators are to be fastened, and should be mounted upon suitable supports or inclosed in suitable boxes, and should be made quite thin, in order to increase their capacity for vibration; and the vibrators are made of sheep-skin or like material, and should be fastened upon the sounding-boards over the openings therein while in a wet and plastic condition, and then have their central portions drawn out and stretched until they assume a funnel-like form, and then be allowed to dry and retain that form.

Now my invention herein claimed relates to the construction of a vibratory apparatus of quite different form and of a much better result from the one hereinbefore described.

It consists, to some extent, of an inclosing-box, within which the vibrators are operated, the box having a suitable opening in and through the end of it which is opposite to the other end of the line of communication, into which vibrations are received and out of which they are delivered; but the apparatus proper consists of two diaphragms or vibrators of the same material before mentioned, and one of them of exactly the same form, and the other of the same general form, but having a central opening in it, to correspond in form and size with the one in the end of the containing-box before mentioned; and these two vibrators, which are in a circular form, by their outer edges are fastened to and upon the two opposite sides of a thin board of soft pine wood, or other vibratory wood or material, with their concave sides next to each other, and the board is cut away in the center, so as to leave a large opening in circular form in it, and the residue of the board serves as a frame for the two vibrators to hold their outer edges distended, and it does not touch the containing-box at all; and the one of the vibrators having the opening in it has the edge around the opening fastened upon another board, which has also an opening in it, corresponding in size and form with the one in the vibrator and the one in the end of the containing-box, and the board is attached to the inside of the end of the box, so that the openings in the vibrator, board, and box constitute an avenue for the reception and delivery of air-vibrations into and out of the apparatus. The transmitting-wire is passed in through the opposite end of the box, and through the apex of the vibrator that has no central opening in it, and is there held by a button on the end of it on the inside of the vibrator, and when the wire is stretched taut both vibrators are stretched and held taut likewise, and the whole apparatus is held suspended upon the wire at one apex, and the attachment to the board (which is attached to the end of the box) at the other, and the result of this construction is a high degree of vibratory power.

My said invention will be more particularly described with reference to the accompanying drawings, in which Figure 1 represents a central vertical longitudinal section of the said apparatus described in my said application filed

October 22, 1878; and Fig. 2, a like view of the containing-box and operative parts of this my improvement claimed herein.

In Fig. 2, *a* indicates the board to which the outer edges of the vibrators are fastened; *h*, the vibrator, attached to the transmitting-wire T by the button *e* and *h'*; the other one of said vibrators, and the same which has the central opening, *n*, in it; and *k*, the board to which that vibrator is attached by the edge around its opening, and it is fastened upon the inside of the end of the box, so that the opening at *n* is through vibrator, board, and box. *g* indicates the cotton or wool placed around the vibrators within the box, in order to destroy the ring of the wire T. The vibrators are stretched and held taut by means of the button *e* on the wire T; and but for the button *i* on the wire outside of the box the vibrators would collapse when the wire was relaxed.

In this construction it will be observed that a large portion of the apparatus is made of the sheep-skin or other animal membrane, and there is in it no more of wood, which is itself capable of a high degree of vibration, than enough for a frame to hold the vibrators in position and proper shape, and that it is therefore very efficient for the purpose of condensing and strengthening air-vibrations for transmission, and I have found it to be so by actual experiment, much more so than the one shown in Fig. 1.

I have found also by experiment that a vibrator that is from seven to eight inches in diameter through the center from one outer edge to the other is the most efficient, and that when they are much smaller than this the vibrations made by the vocal organs are of a nasal character; but when an apparatus of proper size is used at one end of the line, then a much smaller one may be used at the other without impairing perceptibly the effect.

A very good effect is secured by using the construction shown in Fig. 2 at one end of the line, and that shown in Fig. 1 at the other.

What I claim as my invention, and desire to secure by Letters Patent, is—

The vibratory apparatus composed of the vibrator *h* and the vibrator *h'*, having the opening *n*, and the suspended board *a* and the fixed board *k'*, constructed and arranged substantially as and for the purpose described.

J. W. MAXWELL.

Witnesses:

I. M. STEPHENS,

A. M. STOUT.

DEFENDANT'S EXHIBIT NO. 11-A.

(No Model.)

J. E. DANN & J. LAPP.

TELEPHONE TRANSMITTER.

No. 338,660. Patented Mar. 23, 1886.

Fig. 1.

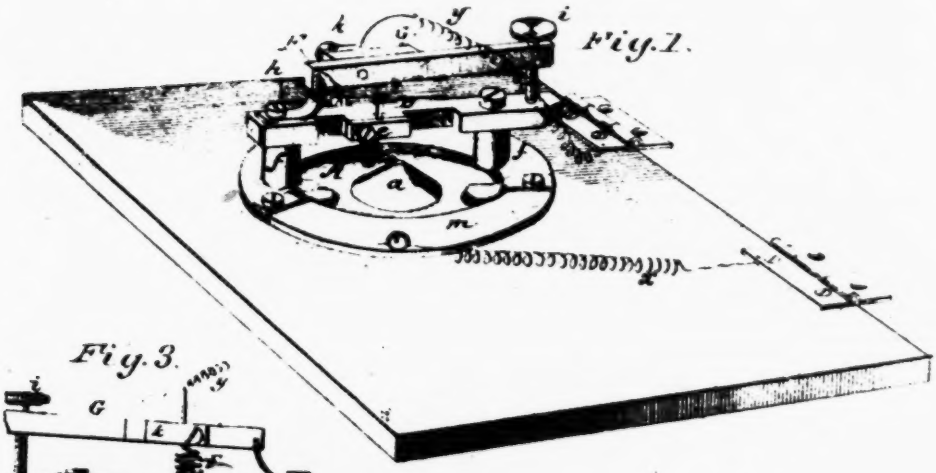


Fig. 3.

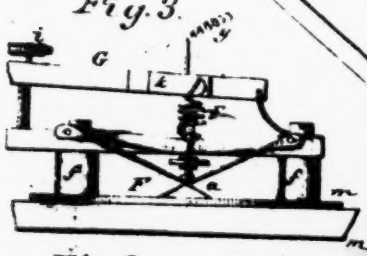


Fig. 2.

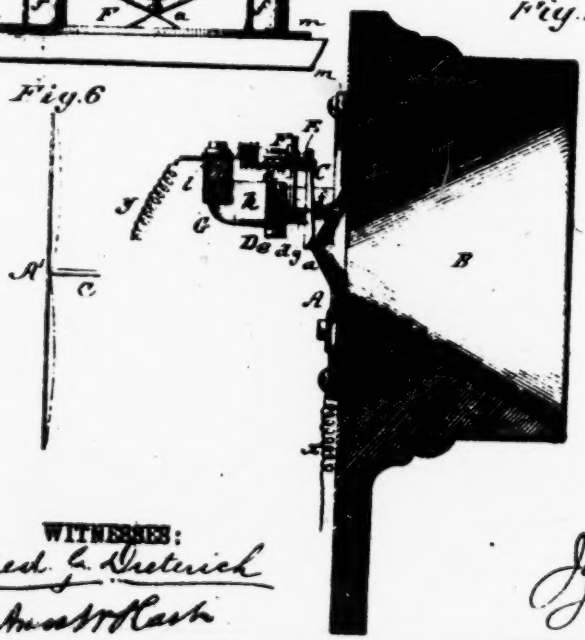


Fig. 4.

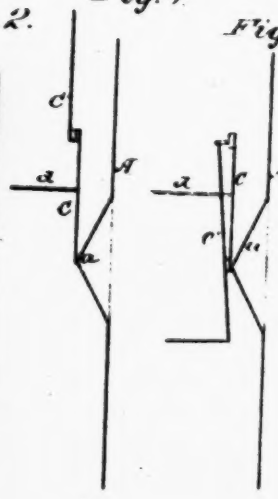


Fig. 5.

Fig. 6.

WITNESSES:

Fred. G. Dieterich

Arnold Kastl

INVENTOR:

John E. Dann

John Lapp

BY Munn & Co

ATTORNEYS.

UNITED STATES PATENT OFFICE.

JOHN E. DANN AND JOHN LAPP, OF HONEOYE FALLS, NEW YORK.

TELEPHONE-TRANSMITTER.

SPECIFICATION forming part of Letters Patent No. 338,660, dated March 23, 1886.

Application filed December 24, 1885. Serial No. 186,644. (No model.)

To all whom it may concern:

Be it known that we, JOHN E. DANN and JOHN LAPP, citizens of the United States, residing at Honeoye Falls, in the county of Monroe and State of New York, have invented a new and useful Improvement in Telephone-Transmitters, of which the following is a full, clear, and exact description.

Our invention is an improvement in the class of transmitters having vibrating electrodes arranged adjacent to and one of them normally pressing upon the diaphragm, and in some cases attached to it.

The object we aim at and have attained is the production of a loud-speaking instrument capable of operating with a minimum expenditure of battery-power or electro-motive force.

To this end we have devised a new and simple construction of the diaphragm, and also provided a new and improved mechanism for co-operating therewith, as hereinafter fully described.

In the accompanying drawings, Figure 1 is a perspective view of our invention applied to the door of a transmitter-box. Fig. 2 is a central cross-section of the same. Fig. 3 is a side view of a portion of the mechanism. Figs. 4 and 5 illustrate modifications. Fig. 6 illustrates a defective operation of the ordinary diaphragm employed in telephones.

The sheet-metal diaphragm A is constructed with a central conical portion, *a*, which may be formed integral therewith or made separately and attached by solder, brazing, or in any other suitable manner. The diameter of the base of the hollow cone may be varied considerably; but we prefer it shall equal and even slightly exceed that of the contiguous inner end of the mouth-piece B, of which it forms practically a conical extension. By this construction and combination of parts the whole force of the air-current or sound-waves from the mouth of the person speaking into the instrument is concentrated on the cone—that is to say, on the central portion of the diaphragm—thereby producing the maximum effect in respect to the required vibration of the latter, and the transmission of sound with corresponding loudness, force, and precision.

A lever, C, which constitutes one of the electrodes, is permanently attached to the apex of the cone *a* through the intermediary of a spring or other device which will allow the lever to vibrate within certain narrow limits. The lever may, however, be rigidly attached to the cone, and in that case of course the diaphragm must yield enough to permit due vibration of the lever. The fulcrum of the latter is a spring or flexible plate, *d*, which is held adjustably by a clamp, *e*, to a fixed bar, D, supported by posts *f*. A shorter lever, C', is arranged parallel to and in front of the former, C, and also attached to its middle portion by a short spring, *g*, which constitutes a yielding fulcrum that permits slight movement of such shorter lever toward and from the other. The outer or free end of this lever C' has an eye or socket that holds the other electrode—to wit, a short metallic pin, E. The latter is suitably insulated in the socket by rubber or equivalent means. The inner end of the pin E rests normally in light contact with the free end of lever C, and it is the vibration of these two parts C and E, corresponding exactly to the vibration of the diaphragm, that effects the transmission of speech.

It is obvious that the contact-points or electrodes proper may be multiple instead of single, although we prefer and intend to use the latter.

When a current is sent through a freely-suspended carbon electrode, it is repelled somewhat from an opposite electrode. We utilize this principle of repulsion as an aid in avoiding the "stick," which two metallic electrodes exhibit, by inserting a piece of carbon in the outer or free end of the lever C, so that the metallic electrode rests in contact therewith, instead of with the lever proper. By this means rapidity of vibration of the electrodes is efficiently promoted, and the instrument thereby adapted to transmit speech with greater fidelity and speed.

As a means of support and adjustment for the pin-electrode C, we connect it by means of a spiral spring, F, with a lever, G, which is arranged parallel with the fixed bar D, and attached to it by a flexible fulcrum-piece, *h*. Said lever is provided with a screw, *i*, at its opposite or free end, for adjusting it closer to or farther from the bar D. A screw-clamp, *k*, secures the spring E to the lever, and it is suitably insulated by a rubber block, *l*.

In practice the diaphragm A and spring F are connected by wires *x y* with the primary of an induction-coil and with a battery, neither of which is shown in the drawings; or the instrument may be set in a battery-circuit with an intensity-coil properly connected with the line-wire. When a sound-wave strikes upon the diaphragm, its main force is concentrated at the center, which is capable of the greatest amplitude of vibration, and the consequent movement of the diaphragm is transmitted to the electrode-lever C, so that the free end of the latter vibrates with a greater amplitude than the diaphragm, owing to the fulcrum *d* being nearer the end attached to the cone *a*. This vibration of the lever-electrode C effects the transmission of sound through the receiving-instrument at the other end of the line.

In addition to the function of the cone *a* in concentrating the sound-waves, as above stated, it has a still more important one, which we will explain as follows: When a sound-wave strikes upon a diaphragm of the usual form with whose center an electrode rests in contact, the latter resists more or less the tendency of such central portion to yield and assume a concavo-convex form, and consequently the portion surrounding the center yields first, as illustrated in an exaggerated way in Fig. 6, in which A′ indicates the diaphragm and C″ an electrode. The result is a failure to transmit and reproduce sound with the desired loudness and accuracy; but by use of the cone *a* this defect is avoided, since the air-wave pressure forces back the cone or central portion of the diaphragm before or else simultaneously with the portion that surrounds it. In other words, the diaphragm vibrates with the freedom and in the manner required to produce, in connection with the other mechanism employed, the desired perfection of result.

A still further advantage attends the use of the cone, since it is capable of withstanding the pressure and thrust to which it is subject in acting on the attached lever, and hence the diaphragm is made correspondingly more durable than if constructed in the usual form.

In further relation to the cone *a* we desire it to be understood that while it is desirable and even necessary that its inner side shall be open, as shown, in order to produce the best result, yet we do not propose to here limit ourselves to such construction, since a good degree of success may be attained by closing the base of the cone—that is to say, by employing a diaphragm of the ordinary form and attaching a hollow cone to its center.

Our improved diaphragm is applicable to other telephonic instruments beside transmitters.

In respect to adjustments it may be stated that the spring-fulcrum *d* of the inner lever-electrode, C, is properly adjusted when the apparatus is prepared or "set up" for use. The lever G is adjusted by screw *i* to increase or lessen the tension of the spring F, and thereby regulate the contact-pressure between the electrodes E C, as required for the desired perfection of operation.

In practical operation of the instrument a metallic sound arises from the molecular or mechanical vibration of movable parts, particularly the electrode-levers and the spring F. To quickly destroy such vibration we employ elastic bands, Fig. 3, which are stretched between suitable points of attachment and press lightly on the spring and pin-electrode E and both levers C and C′, as shown. It is also expedient to employ dampers or elastic pressure-plates, as shown in the drawings, to limit the vibration of the diaphragm, and thus choke out the metallic clang.

We do not propose to limit our invention to the described and preferred arrangement of levers shown, since various others are practicable. As an example, the outer electrode might be attached to the lower end of a metal strip or bar, C′, as shown in Fig. 4, and said bar may be a spring, or it may be inelastic, and in the latter case the action of gravity would be depended on to hold it in light contact with the other electrode, C.

Fig. 5 illustrates still another arrangement, wherein both levers C C′ are attached to the cone, which thus acts directly on both when vibrated.

We are aware that a diaphragm having a conical portion with a surrounding annular part which is curved transversely (or in cross-section) has been suggested or employed, and we therefore restrict our claim to the precise construction of our diaphragm, which experiment has demonstrated to be advantageous.

We propose to file another application in which the function and advantages of a carbon electrode in transmitters of this particular class shall be fully described, and in which it shall be claimed more broadly than in this application.

What we claim is—

1. The diaphragm having a central hollow cone and a surrounding annular part, all portions of which are flat or lie normally in the same plane, said diaphragm being free to vibrate, as shown and described.

2. The combination, with the diaphragm and its central hollow cone, of electrode-levers having yielding fulcra, and one of them attached to said cone, substantially as shown and described, to operate as specified.

3. The combination of the spring F with the connected electrode-levers, the spring or elastic fulcra therefor, the diaphragm having a hollow cone to which one of said levers is attached by a yielding connection, all as shown and described.

4. The combination of the spring F with the pin-electrode, the lever C, and the cone-diaphragm, substantially as shown and described.

5. In a telephone of the character herein-

before specified, the combination, with the diaphragm and an electrode, E, of the lever C, connected with the diaphragm and carrying a carbon contact-point.

6. The combination, with the diaphragm and the lever-electrode C, attached thereto, and the spring-fulcrum *d* therefor, of the electrode C' and its spring-fulcrum *g*, substantially as shown and described.

7. The combination, with the diaphragm and the vibrating lever-electrode C, attached thereto and having a spring-fulcrum, of the second electrode-lever, C', and a spring-fulcrum therefor, which connects it with the other, C, at a point between the fulcrum and free end of the latter, as shown and described.

8. The combination, with the diaphragm, the electrode-levers, the spring F, and a fixed bar, D, of the adjusting-lever G and the screw *i*, all arranged as shown and described to operate as specified.

JOHN E. DANN.
JOHN LAPP.

Witnesses:
AMOS W. HART,
P. B. TURPIN.

2

N° 3393.—A.D. 1901.

Improvement in the Diaphragms of Phonographs, Musical Instruments, &c.

COMPLETE SPECIFICATION.

Improvement in the Diaphragms of Phonographs, Musical Instruments, and analogous Sound-producing Recording or Transmitting Contrivances.

I, JOHN MATTHIAS AUGUSTUS STROH, Electrical Engineer, of 98, Haverstock Hill in the County of London, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The diaphragms of phonographs, graphophones, and analogous sound-producing or transmitting instruments are usually made in the shape of a flat circular disc which is supported at its edges and free to vibrate in the centre.

If such a diaphragm is set in motion by means of a solid body acting on the centre, the amplitude of the vibrations is a maximum in the centre and gradually diminishes towards the circumference, and the waves of air produced by such a diaphragm differ therefore according to their distance from the axis of the diaphragm.

The present invention has for its object, to increase the efficiency and uniformity of the vibrations, and thereby to increase the quality of the sounds, or the accuracy of their reproduction. For this purpose I make the centre of the diaphragm rigid by giving it the shape of a cone having its apex at the point where vibrations are imparted to the diaphragm or transmitted by the same, while the annular portion between the base of the cone and the edge of the diaphragm may be flat or corrugated, the number and depth of the corrugations depending on the nature of the diaphragm and on the effect desired. When the vibrations are imparted to the diaphragm from the centre, the conical part will move up and down as a whole, without materially altering its shape, while the corrugated part yields to each movement of the cone, and as the cone occupies preferably about two-thirds of the diameter of the diaphragm, a larger stratum of air will be set in motion, or the vibrations will be more uniform than in the case of a flat diaphragm. The concentric corrugations of the rim facilitate the motion of the cone in the direction of its axis, while preventing or impeding vibrations in any other direction, which accidental or irregular vibrations are supposed to be the cause of impure sounds. The diaphragm may be made of metal, ebonite, celluloid, or other suitable material, and the most suitable thickness should be ascertained by experiments.

This invention is applicable to phonographs, graphophones, and other instruments, in which the production of sound depends upon the vibration of a diaphragm, or where a diaphragm is used for transmitting vibrations of a solid body to a stratum of air, for instance, in the violins or other stringed instruments described in my Patent Specification No. 9,418 of 1899.

According to the present invention the diaphragms of violins and similar stringed instruments are made conical in the centre and corrugated at the circumference.

In the drawings filed with the Provisional Specification Fig. 1 is an axial section of a diaphragm embodying my invention, as applied to a violin.

Fig. 2 represents a modification, and Fig. 3 another modification.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

instruments, a diaphragm which is conical in the centre and flat or corrugated at the circumference, substantially as described and for the purpose specified.

2. In musical instruments of the violin class, having a sound-producing diaphragm adapted to receive mechanical vibrations in the centre and to communicate them to a stratum of air, the improved shape of the diaphragm, substantially as described and for the purpose specified.

Dated this 6th day of November 1901.

FAIRFAX & WETTER
Patent Agents. 37 & 39, Essex Street, Strand, London.

A.D. 1901, Feb. 16. No. 3393.

STROH'S PROVISIONAL SPECIFICATION. (1 SHEET)

Fig 1

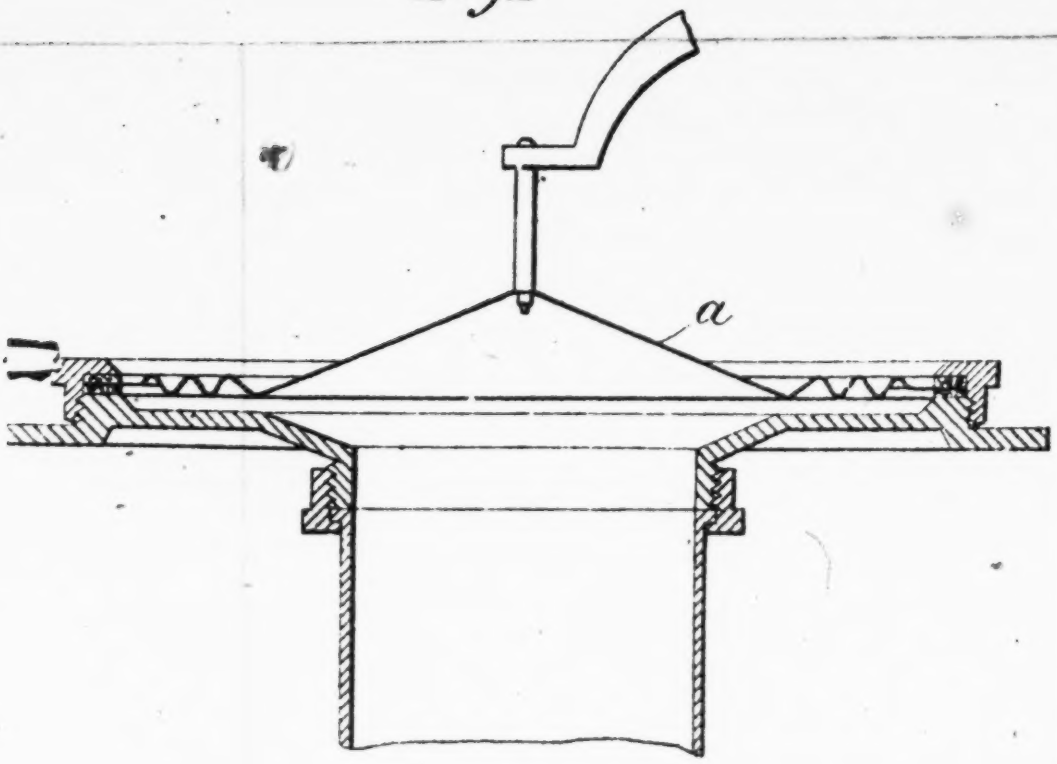


Fig. 2.

Fig. 3.

[This Drawing is a reproduction of the Original on a reduced scale.

DEFENDANT'S EXHIBIT NO. 11-C.

No. 890,142. PATENTED JUNE 9, 1908

T. KRAEMER.

SOUND BOX FOR TALKING MACHINES.

APPLICATION FILED OCT. 7, 1907.

Fig. 1.

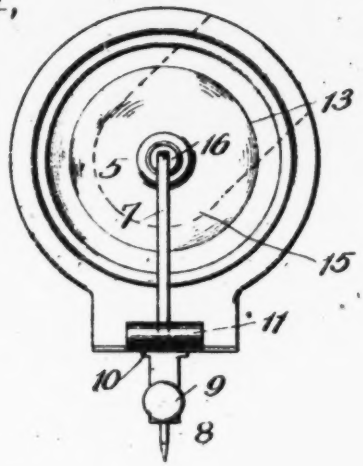


Fig. 2.

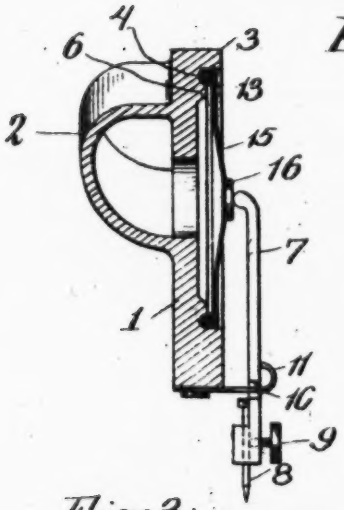
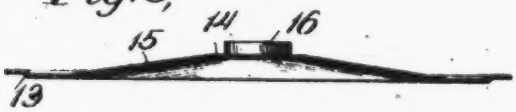


Fig. 3.



WITNESSES:

I. McIntosh

A. Edmunds.

INVENTOR

Thomas Kraemer.

BY

J. C. Edmunds

ATTORNEY

UNITED STATES PATENT OFFICE.

THOMAS KRAEMER, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO HAWTHORNE & SHEBLE MANUFACTURING COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

SOUND-BOX FOR TALKING-MACHINES.

No. 890,142. Specification of Letters Patent. Patented June 9, 1908.

Application filed October 7, 1907. Serial No. 396,135.

To all whom it may concern:

Be it known that I, THOMAS KRAEMER, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented a certain new and useful Improvement in Sound-Boxes for Talking-Machines, of which the following is a specification.

This invention relates to sound-boxes for talking machines and has reference more particularly to the construction of the diaphragms for such sound-boxes.

The object of the invention is to effect certain improvements in the construction of such diaphragms to the end that a greater volume of sound is obtained in reproducing a record and that a more faithful reproduction is obtained as a result of the elimination of false sound vibrations.

I have illustrated the preferred embodiment of my invention in the accompanying drawings, in which

Figure 1 is a front view of a sound-box, Fig. 2 is a central section of the same, and Fig. 3 is an enlarged sectional view of the diaphragm alone.

Referring to these drawings, the sound-box is show as having a main wall 1, a tubular extension 2 leading therefrom for connection to the sound-conveying tube, and a circular flange 3 at the outer edge of wall 1 forming the outer wall of the box. Fitting snugly within wall 3 is a rubber strip or ring 4, circular in cross-section, forming a support for the diaphragm 5, this ring being retained in position by a circular ridge 6 integral with and rising from the wall 1. The stylus-lever 7 is pivotally mounted upon the wall 3, bears at its inner end upon the central portion of the diaphragm, and at its outer end is provided with an opening to receive a stylus 8, the latter being held in its opening by a set-screw 9. In the present instance, I have shown the stylus-lever as provided with notched lugs 10 adapted to receive knife-edges formed on a sheet-metal piece 11 which is secured to wall 1 and whose end forms a spring 12 tending to rock the stylus-lever on its knife-edge pivot in the direction to hold its inner end against the diaphragm.

The method of mounting the diaphragm herein shown with its edge bearing on a rubber ring has proven highly efficient as the rubber absorbs counter-vibrations and thus makes the reproduced sound much more clear. The diaphragm, which is a disk of thin sheet-metal, is of a diameter but little less than the internal diameter of the circular flange 3 and when in proper position it rests upon the rubber ring 4 with its outer edge separated from the interior wall of flange 3 by a narrow space entirely around the diaphragm. It is difficult, however, to get the diaphragm in this position every time it is inserted and to retain it there during long periods of use of the sound-box and if the diaphragm becomes moved out of this position the small amount necessary to carry its edge into contact with the flange 3, the vibrations of the diaphragm will be transmitted to the sound-box and the reproduced sound will be much less clear and distinct. I therefore provide means for centering the diaphragm in position and holding it against such movement as would cause its edge to engage the wall of the box. This is accomplished by providing a circular rib 13 in the diaphragm concentric with and close to the outer edge thereof, such that when the diaphragm is in position, this rib will coact with the rubber ring 4 to obstruct movement of the diaphragm in the plane in which it lies.

In Fig. 2 of the drawings, it will be seen that the rib 13 is in coaction with the ring 4 and would preclude movement of the diaphragm in a vertical direction and that when in this position the edges of the diaphragm are separated from the wall of the sound-box. So long as the diaphragm is held in this position, the danger of transmitting the vibrations thereof to the walls of the sound-box is eliminated.

In diaphragms for sound-boxes as heretofore constructed, especially those which are flat disks, the vibrating area is small and therefore the air-pressure behind the diaphragm is also small. In accordance with my invention, I construct the diaphragm in such manner that the area of vibration is considerably increased. This is accomplished by pressing a comparatively large portion of the diaphragm at its center out of the plane thereof so that the central portion of the diaphragm swells out to one side. This is shown in Figs. 2 and 3, from which it will be seen that the center 14 of the diaphragm is displaced from the plane of the edge portion thereof. The inclined portion

15 joining the center 14 and the edge portion includes a considerable part of the total area of the diaphragm and when the stylus-lever is rocked to and fro on its pivot by the undulations of the record-groove, this entire inclined portion is caused to vibrate so that a vibrating area is obtained which is considerably larger than that obtained when a flat disk is employed as a diaphragm. This increased area of vibration results in increased air-pressure behind the diaphragm and both of these combine to give a considerably increased volume of reproduced sound.

The diaphragm above described may be pressed to the desired shape from a disk of sheet-metal and may therefore be manufactured at very low cost. A metallic button 16 is preferably secured to the center of the diaphragm on which the inner end of the stylus-lever bears.

Having now described my invention, what I claim as new therein and desire to secure by Letters Patent is as follows:—

1. The combination of a sound-box having an outer wall, a resilient member within said wall, and a diaphragm supported on said member with its edge out of contact with said wall said diaphragm having a rib therein coacting with said member to prevent movement of the diaphragm in the plane in which it lies, substantially as set forth.

2. The combination of a sound-box having an outer wall, a rubber ring within said wall, a ridge on the sound-box to retain said ring in position, and a diaphragm supported on said ring with its edge out of contact with said wall, said diaphragm having a rib therein close to its outer edge coacting with said member to prevent movement of the diaphragm in the plane in which it lies, substantially as set forth.

3. The combination of a sound-box having a wall and shaped to provide a surface within the box adjacent to said wall for supporting a diaphragm, and a diaphragm supported on said surface, said diaphragm having a rib therein coacting with a part of the box structure to preclude movement of the diaphragm in the plane in which it lies to carry its edge into engagement with said wall of the box, substantially as set forth.

This specification signed and witnessed this 30 day of Septr., 1907.

THOMAS KRAEMER.

Witnesses:
H. MEIER,
H. MUHLSCHLEGEL.

L. LUMIERE.

ACOUSTICAL INSTRUMENT.

APPLICATION FILED JUNE 30, 1909.

986,477. Patented Mar. 14, 1911.

5 SHEETS—SHEET 1.

Fig. 1.

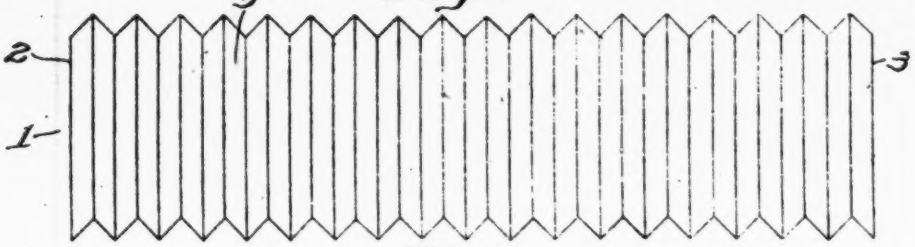


Fig. 2.

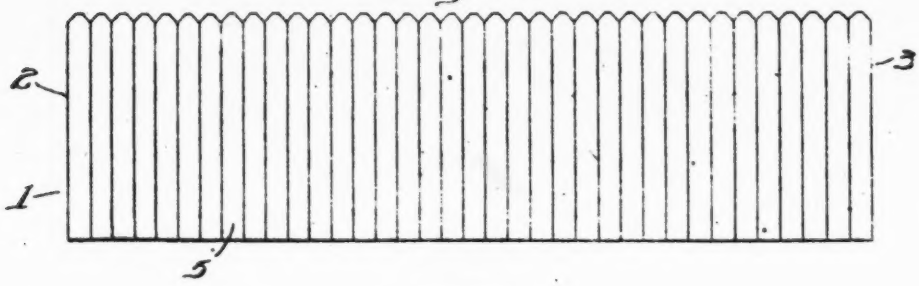


Fig. 3.

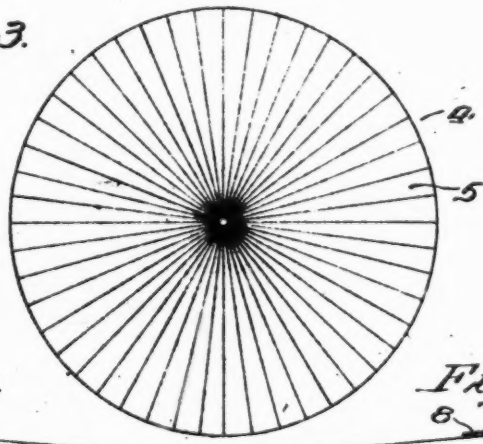


Fig. 4.

Fig. 5.

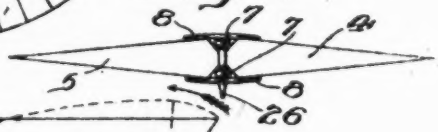
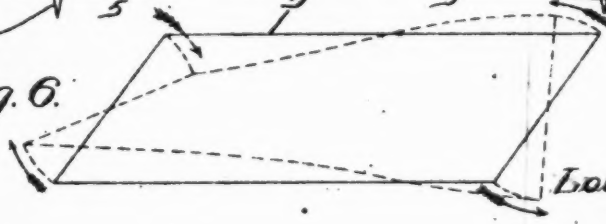


Fig. 6.



INVENTOR

Louis Lumiere

WITNESSES

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Hexton B. Maulton

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ACOUSTICAL INSTRUMENT.

APPLICATION FILED JUNE 30, 1909.

986,477.

Patented Mar. 14, 1911

5 SHEETS-SHEET 2.

Fig. 7.

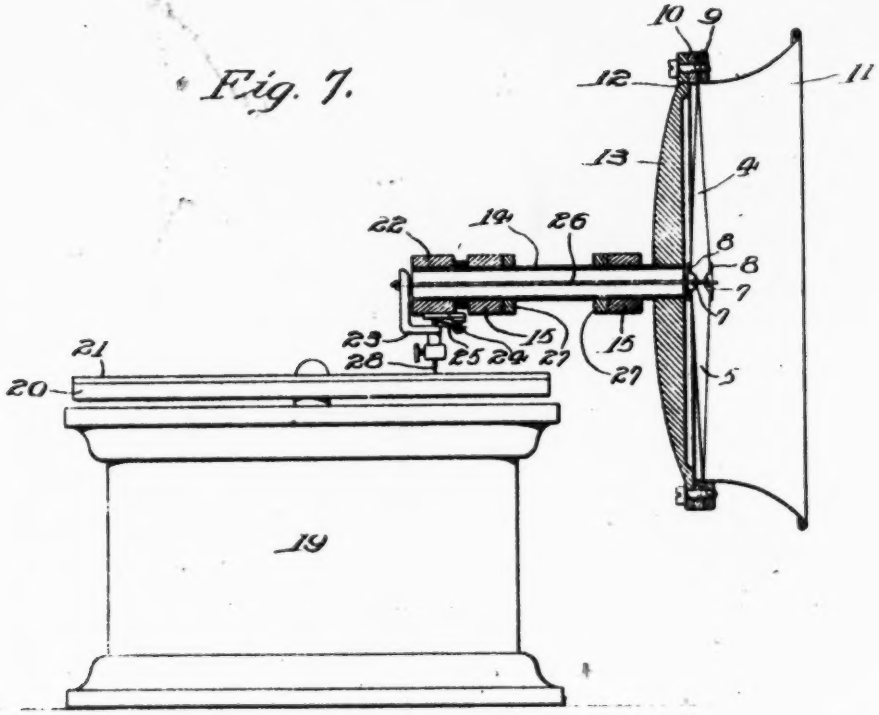
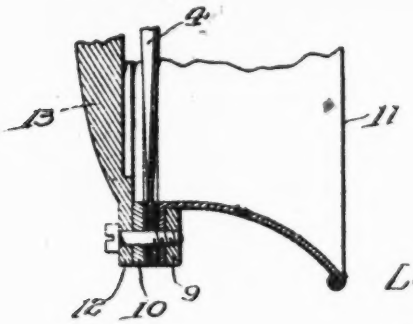


Fig. 7.a



INVENTOR

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WITNESSES

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Howe Pettit.

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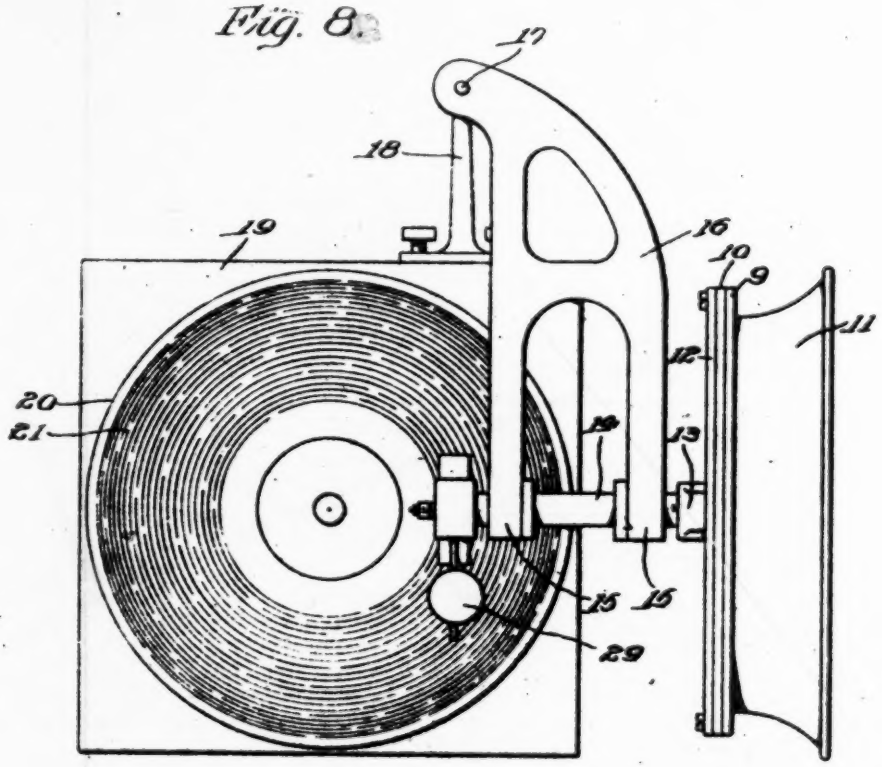
ACOUSTICAL INSTRUMENT.

APPLICATION FILED JUNE 30, 1909.

986,477. Patented Mar. 14, 1911.

5 SHEETS—SHEET 3.

Fig. 8.



INVENTOR

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ACOUSTICAL INSTRUMENT.

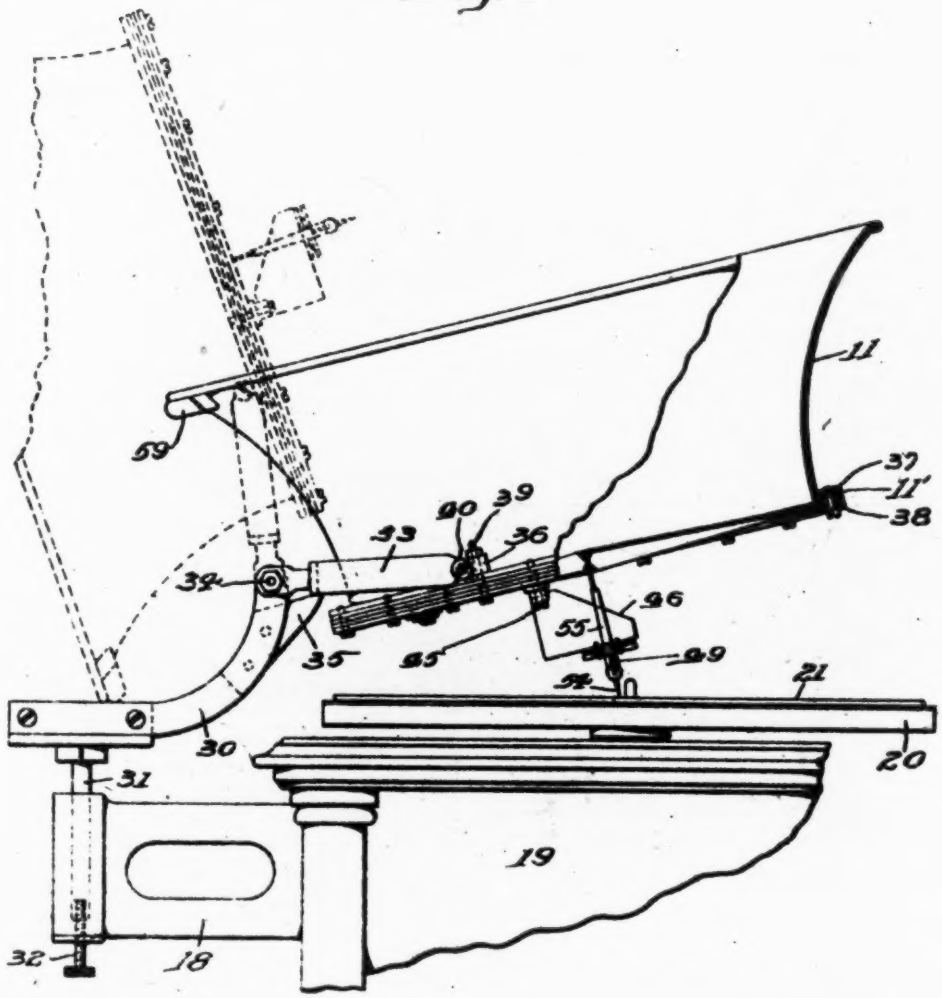
APPLICATION FILED JUNE 30, 1909.

986,477.

Patented Mar. 14, 1911.

5 SHEETS—SHEET 4.

Fig. 9.



INVENTOR

Louis Lumiere

WITNESSES

W. J. Hauttmans.

Horace B. Hunt

BY Horace Pollock.

ATTORNEY

490

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ACOUSTICAL INSTRUMENT.

APPLICATION FILED JUNE 30, 1909.

986,477. Patented Mar. 14, 1911.

5 SHEETS—SHEET 5.

Fig. 10.

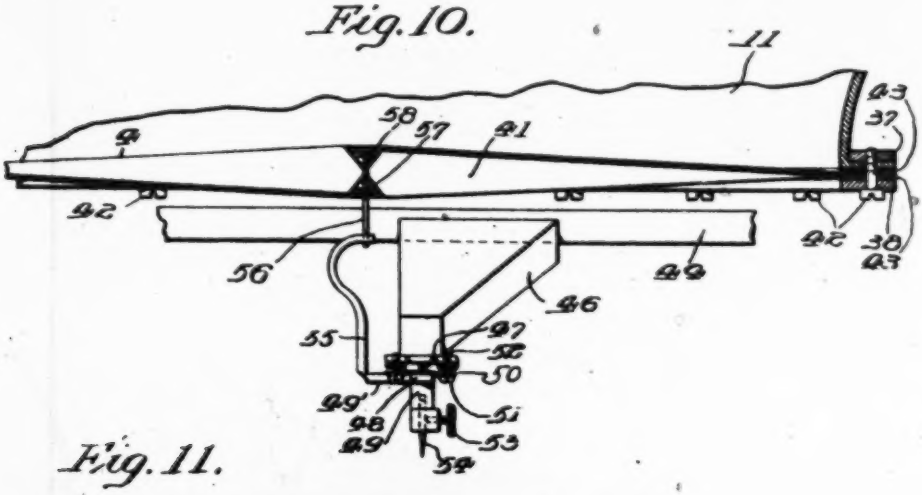
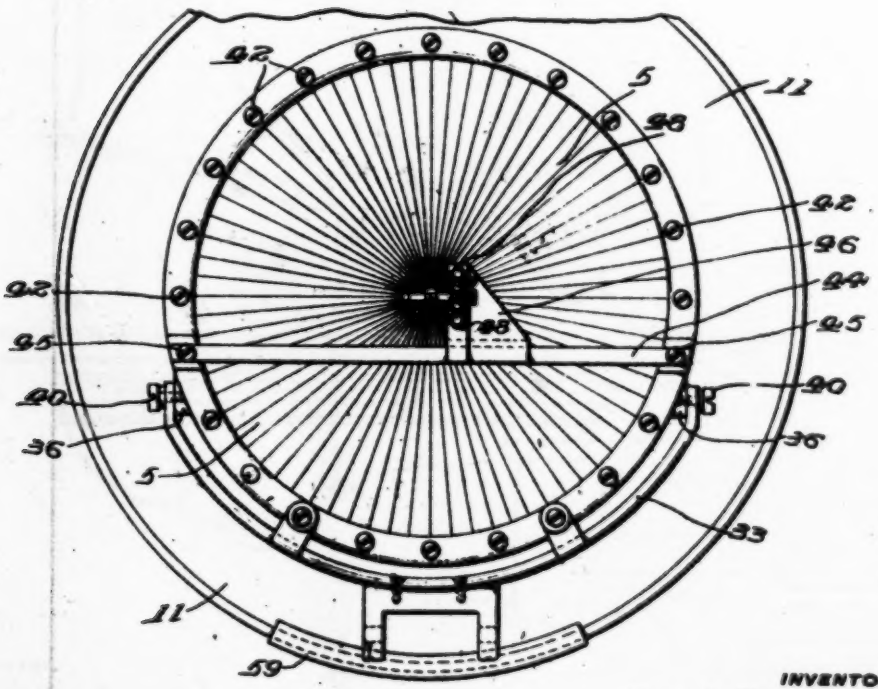


Fig. 11.



INVENTOR

Louis Lumiere.

WITNESSES

F. J. Hastuaw.

BY Howard Taylor.

ATTORNEY

UNITED STATES PATENT OFFICE.

LOUIS LUMIERE, OF LYON, FRANCE.

ACOUSTICAL INSTRUMENT.

986,477. Specification of Letters Patent. Patented Mar. 14, 1911.

Application filed June 30, 1909. Serial No. 505,149.

To all whom it may concern:

Be it known that I, LOUIS LUMIERE, a citizen of the Republic of France, residing at Lyon, in the Republic of France, have invented certain new and useful Improvements in Acoustical Instruments, of which the following is a full, clear, and complete disclosure.

This invention relates to improvements in acoustical instruments, such as telephones, microphones, sound recording and reproducing machines, and musical instruments in general. As applied to sound recording and reproducing apparatus, it relates more particularly to that part of the instrument which is generally known as the diaphragm, or the body which in the process of sound recording is thrown into vibration by the sound waves, and whose vibrations are traced and recorded by means of a stylus in the original record, while in the process of reproduction the diaphragm, (as a general rule, the diaphragm of a separate machine), is thrown into corresponding vibrations by a stylus to which it is attached being made to follow the undulations in the record.

The invention also relates to the sound box in which said diaphragm is mounted.

The object of my invention is to provide a diaphragm and a mounting therefor, by means of which sounds may be faithfully recorded and reproduced, which will be sensitive to sound waves and by the use of which the reproduction of sound will be improved and amplified.

Further objects of my invention are to increase the reproducing surface of a diaphragm, and, at the same time, to place the entire surface under a tension, (preferably torsional), to make it sensitive; to increase the active surface of a diaphragm of a certain given diameter; to increase the diameter of the diaphragm without making it liable to vibrate in parts, or to set up nodes or inactive portions in the diaphragm, or, in other words, to substantially increase the size of the diaphragm and, at the same time, have it vibrate throughout; to construct a diaphragm having a plurality of sound responsive elements, each of which is subjected to a molecular tension, and to subject each of a plurality of sound responsive elements to a molecular tension to increase the sensitiveness thereof and to cause them to vibrate as a whole.

Further objects of my invention will be found in the specification and claims below.

The invention consists in a diaphragm for acoustical instruments, having one or more freely resilient, sound responsive surfaces or elements, which have been brought into a condition of molecular stress, of an aggregate superficial area substantially larger than the surface of a plane disk of the same diameter, and in a recorder or reproducer in which said diaphragm is mounted.

It is found that the effect of bringing the surfaces of a vibrating body into a condition of molecular stress by torsion, is to reduce to a minimum the tendency of the vibrating body to form nodes during operation, so that the surface or surfaces of the diaphragm will vibrate as a whole and will not produce the disagreeable effect which is technically known as blasting or shattering.

One construction of diaphragm made according to this invention and the method of making it is illustrated in the accompanying drawings, in which:—

Figure 1 shows a folded strip of material from which the improved diaphragm may be made; Fig. 2 is a plan view of a modified form of folded strip of material from which a diaphragm may be made; Fig. 3 is a plan view of the diaphragm; Fig. 4 is a sectional elevation of the diaphragm; Fig. 5 is a sectional elevational view of a slightly modified form of diaphragm; Fig. 6 is a diagram to illustrate the way in which the surfaces or elements of the diaphragm are twisted; Fig. 7 is an elevation of a sound reproducing machine fitted with the diaphragm made in accordance with this invention and illustrates a convenient method of carrying the diaphragm and connecting it to the stylus bar; and Fig. 7ª is a sectional detail of Fig. 7. Fig. 8 is a plan view of the machine shown in Fig. 7; Fig. 9 is a side elevational view partly in section of a modified form of sound reproducing machine provided with my invention; Fig. 10 is an enlarged view, partly in section, of the diaphragm and stylus bar mounting shown in Fig. 9; and Fig. 11 is a bottom plan view of the reproducer shown in Fig. 9.

According to one method of carrying out this invention, a diaphragm is constructed so that it presents the form shown in Figs. 1, 3 and 4 of the accompanying drawings, in

which the whole surface of the diaphragm on either side consists of a plurality of elements reversely flexed to form a fan-like series of radially disposed ridges and furrows, the ridges on one side of the diaphragm corresponding to the furrows on the other side of the diaphragm, and the furrows gradually widening out and becoming less deep as they approach the edge of the diaphragm until at its perimeter the diaphragm lies in one plane. The elements forming the sides of the ridges and furrows provide the desired freely resilient sound responsive surfaces. A diaphragm of this form may be obtained by folding or plaiting a substantially rectangular strip of paper 1, or other suitable material in the manner shown in Fig. 1. The length of the strip of material before folding should be substantially the length of the circumference of the diaphragm to be formed therefrom, and the width of the strip should be substantially equal to the radius of the said diaphragm. When the strip has been plaited or folded in the manner above described and shown, the ends 2 and 3 should be brought together and secured to each other in any suitable manner. At this stage of the process or method, the strip will present, roughly speaking, the appearance of a cylinder having fluted sides. This strip of material is then pressed down and forced to assume the form shown in Figs. 3 and 4, one edge of the strip being crimped together at the center, and the other edge forming the perimeter; the radial ridges and furrows, or plaits being closest together and of greatest depth at the center, and gradually opening out and flattening toward the edge where the diaphragm may be held in one plane between clamping rings, as shown in Figs. 7 to 11. In Fig. 3 the diaphragm is designated as 4 and the elements forming the plaits or ridges and furrows are designated by the numeral 5. The diaphragm 4 thus formed in the manner above described will be seen to have a surface formed wholly of a multiplicity of flexed sound responsive elements, reversely sloped or angled to each other, forming dihedral ridges. The surface of the diaphragm will consist of a surface comprising salient radial angled surfaces, and radial reëntrant angled surfaces. Any sector of the surface will have a fan-like formation.

To the center of the diaphragm, is attached, in any suitable manner, the recording or reproducing stylus 6, as the case may be. As shown in Fig. 4, the diaphragm is for use with or for a record having an up and down, or vertical cut, since the diaphragm is directly provided with a stylus at its center.

For making the attachment between the stylus and diaphragm, or between the connection between the stylus and the diaphragm, I prefer to bevel off the inner edge of the diaphragm as particularly shown in Figs. 2, 9 and 10. The stylus 6 may be secured directly to the inner edges of the elements of the diaphragm by being cemented or glued thereto in the manner shown in Fig. 4, or it may be secured in place by means of nuts 7, as will be more particularly described below, in connection with the form of apparatus shown in Figs. 9 and 10 and also as shown in Fig. 5. The stylus 6 may also be surrounded by rings of stiff paper 8, secured on either side of the diaphragm at the center thereof to give it additional rigidity at that point. I do not, however, limit myself to this form of connection. The effect of constructing the diaphragm in this manner, is that the whole diaphragm, *i. e.*, the surface of each element of each ridge and furrow is under molecular stress, produced by torsion, but the sides of the ridges and furrows are twisted out of the plane in which they lie at the center of the diaphragm into a plane, practically at right angles thereto at the circumference of the diaphragm. I have further found that in a diaphragm produced by this means, the tendency of the vibrating body to form nodes during operation is reduced to a minimum. The surface of each of the elements composing this diaphragm being helicoidal, and since each point in the vibrating body, as it moves, follows a direction normal to the tangential plane at this point, the result is that the direction of movement is different for each point that has to be considered so that the formation of nodes is practically impossible. It is obvious, of course, that the same condition of molecular stress would be produced upon twisting a sheet of material which naturally possessed a helicoidal or other than plane form so as to take up a position in a true plane, or other helicoidal form of different pitch.

The diagram shown in Fig. 6, illustrates clearly the torsion which is applied to each of the multiple surfaces or elements of the diaphragm when the strip of material is made to take up the form shown in Figs. 3 and 4 from the form shown in Fig. 1. In this diagram 5′ represents a thin flat sheet of elastic material, such as is formed by each of the several folds or plaitings of the strip shown in Figs. 1 and 2. If the two ends of this sheet are turned in opposite directions, as indicated by the arrows, and are made to take up the position shown in dotted lines, it is found that a very resilient body is formed, which is capable of vibrating more readily, and is more sensitive, *i. e.*, more sound responsive in its new position than it was before. This is probably due to the molecular stress which is imparted to it by this twisting action. It will be clear that each of the

surfaces or folds 5, of the diaphragm illustrated in Figs. 3 and 4 is in the same condition of molecular stress, as the sheet 5' in Fig. 6.

The width of the folds 5, relative to the breadth of the strip in which they are made, may vary; but I have found a convenient proportion to adopt when making the diaphragm of paper is about 10 to 1, so that each fold of the strip is 10 times as long as wide.

I have found that in a diaphragm having multiple resilient surfaces such as that above described, a greatly improved reproduction can be obtained. Moreover, a diaphragm constructed in the manner above described can be usefully made of considerably greater diameter than has heretofore been possible. Experience has seemed to prove that a plane diaphragm of mica, or other material, such as is used at the present day, if made of more than about three-and-a-half inches in diameter, loses in quality of reproduction, the reproduction becoming less musical and there being a liability to what there is technically known as "shattering", due probably to the diaphragm not vibrating as a whole, *i. e.*, to the setting up of nodes in the diaphragm. I have found, however, that I am able to make a diaphragm according to the present invention, as large as ten inches or more in diameter, without impairing the quality of the reproduction, and by means of this diaphragm, I at the same time, attain a much greater volume of sound than with the smaller diaphragm. This amplification of the sound, I believe to be due, not only to the increased diameter of the diaphragm, but also to the increased surface area of the diaphragm produced in the construction above described, by the plaitings or crimpings or folds in the material of the diaphragm; this appears to have the effect of putting into motion a greater volume of air and so increasing the volume of sound.

A diaphragm having freely resilient sound responsive surfaces brought into a condition of molecular stress, preferably by torsion, and also of an aggregate area substantially larger than a plane disk of the same diameter may of course be produced in other ways than that above described. I have found, however, that the above described method is a convenient one for making the diaphragm.

The advantage arising from the use of a diaphragm constructed as above described, is that the volume of sound produced is sufficient to enable me to dispense with the usual amplifying horn, and in this way, much of the metallic and hollow character usually associated with talking machine reproductions is eliminated.

Diaphragms may be made according to this invention, of any suitable elastic material, such as paper, (which may be varnished if desired), card, celluloid, metal, or the like, and the surface, or surfaces, of the diaphragm, or elements composing the vibrating body, may be put under tension by any suitable means.

One means of mounting the stylus bar and diaphragm in an operative position particularly for use with a record having a record of sound in the form of a groove having lateral undulations in the walls thereof is shown in Figs. 7 and 8. In this case, the diaphragm 4 is held at the edges by clamping rings 9 and 10, and, to the front ring 9, may be secured a small trumpet 11 for directing the sound waves. The clamping ring 10 is fixed to a suitable backing ring 12, having radial arms 13 by which the same is carried by a tube 14 which is capable of turning freely in the bearings 15—15, of the swinging arm 16, pivoted at 17 upon a rigid bracket 18, fixed to the cabinet 19. The cabinet 19 is provided with a suitable mechanism for rotating the turn-table 20 upon which a record 21 is carried in the usual manner.

The tube 14 is provided at one end with a mounting 22 freely rotatable upon said tube 14, but prevented in any suitable manner, from longitudinal movement upon the tube 14. This mounting 22 carries a stylus bar 23 which may be mounted thereon in any suitable manner, as by being pivoted on the knife edges 24, and retained on said knife edge bearings by a spring 25, in the usual manner. The upper end of the stylus bar 23 is connected by a rod 26 with the diaphragm 5, the rod 26 being connected or attached to the diaphragm by nuts 7 in the manner shown in Fig. 5. In this construction as shown in Figs. 7 and 8, the diaphragm is preferably made from a sheet of material such as is shown in Fig. 2 of the drawings so as to provide a suitable recess on each side of the diaphragm, in which the nuts 7 are seated. These nuts may be further cemented or otherwise secured to the diaphragm. In the said figures the diaphragm is also shown as being provided with a stiffening ring 8 at the center of the diaphragm and surrounding the stylus bar connection 26. Suitable nuts or collars 27 may be employed for holding the tube 14 from lengthwise movement in the bearings 15.

As the stylus 28 follows the record groove, the arm 16 will swing across the record on the pivot 17, and the mounting 22, carrying the stylus bar 23, will oscillate around the tube 14 with any unevenness in the rotation of the record. A suitable weight 29 may be attached to the mounting 22, to cause the stylus to engage the record with the requisite amount of pressure.

In Figs. 9, 10 and 11, I have illustrated a further modification of the way in which

my diaphragm may be used in connection with a sound reproducing machine. In said figures, the record 21 is supported upon and rotated by a turn-table 20 driven by any suitable motor within the casing 19, and the cabinet is provided with a bracket 18 similar to the arrangement above described in connection with Figs. 7 and 8. An arm 30 is mounted upon a steam or pintle 31 to swing on said bracket in a plane substantially parallel with the plane of the record 21. The bracket 18 may be provided with a vertically adjustable step 32 for the end of the stem 31, which, in the form illustrated in Fig. 9, consists of a screw threaded into the bracket 18, and against which the end of the stem or pintle 31 rests. By this means, the arm 30 may be raised or lowered to adjust the parts carried thereby with respect to the record 21 on the turn-table 20, to set the stylus at the proper angle to the record surface. The free end of the arm 30 carries a yoke 33 pivoted to the said arm by a bolt or pin 34, so as to be capable of swinging in a plane substantially perpendicular to the plane of the record. The said arm 30 is provided with a stop 35, which prevents the yoke from swinging downwardly beyond a predetermined point. The outer ends of the yoke 33 are secured to lugs 36 bolted to the rings 37, 38, by bolts 39, passing through said rings and said lug. Screws 40, passing through the ends of the yoke 33 and into the lugs 36, form the pivots to permit the rings and the parts carried thereby, to oscillate thereon. The diaphragm 41 is of the kind which I have described above; that is to say, the diaphragm is formed by reversely folding a sheet of material to form plaits, each plait forming an element of the diaphragm, and each of these plaits or elements is subjected to a torsional tension or strain by the bringing of the folded or plaited sheet of material into a substantially circular form. In these Figs. 9 to 11, the diaphragm is shown practically as being formed from a sheet of material such as is shown in Fig. 2; that is to say, a strip in which each plait is cut away at its inner corners so as to form a recess on each side of the center of the diaphragm to permit of a convenient attachment of the stylus bar to the diaphragm. As is plainly shown in Fig. 10, the diaphragm 41 is clamped between the rings 37 and 38, and securely held in that position by means of the screws 42 passing through the said rings and drawing them together. I prefer, however, to interpose, between the rings 37 and 38, and the diaphragm, thin rings 43—43 of a suitable non-metallic and preferably slightly elastic material, one on each side of the diaphragm. These rings 43, may be of fabric, or rubber, or fiber, or any other suitable material to prevent an actual contact between the diaphragm and the metallic rings 37 and 38, and to securely hold the periphery of the diaphragm in a single plane. A suitable small trumpet 11 may be also secured between the rings for the purpose of directing the sound waves. I have shown it plainly in Figs. 9 and 10 as composed of a slightly flaring substantially conical member having a flange 11′ clamped between the rings 37 and 38, the screws 42 passing therethrough. The periphery of the diaphragm 41 is clamped between the intermediate rings 43, and held thereby in a single plane as plainly shown in Fig. 10.

The bottom of the reproducer is provided with a suitable support for the stylus bar, said support comprising a bar 44 secured to the ring 38 by screws 45, or in any other suitable manner. The said bar 44 may carry a block 46 rigidly secured thereto and upon the lower side of said block, I mount the stylus bar. Any suitable mounting for the stylus bar may be employed, but in the said modification illustrated in Figs. 9 to 11, I have shown the block 46 as provided with a pair of alined knife edges 47 engaging suitable recesses and lateral extensions 48 of the stylus bar 49. Each lateral extension is provided with a spring 50, one end of which is attached to said extension 48, and the other end of which extends outwardly and is provided with a hole through which a screw 51 passes, the head of the screw engaging the end of said spring 50 and the screw being threaded in a suitable tapped plate 52 carried by the said block 46. In this way the stylus bar is yieldingly held upon the knife edges 47, but is free to oscillate upon them as bearings. The lower end of the stylus bar is provided with a suitable set screw 53 for securing the stylus 54 in the socket therein. The stylus bar 49 may have a portion 49′ extending at an angle to the stylus-carrying portion and it may then extend upwardly as at 55 to this point of attachment to the center of the diaphragm. I have shown the said upwardly extending portion 55 as being curved in order to make it slightly yielding, and the point between the portions 49′ and 55 as being materially weakened to enable the stylus bar to readily bend or spring or give slightly at this point to transform the vibratory movement of the stylus into a reciprocatory movement of the portion 55 which is directly attached to and consequently communicates its motion to the center of the diaphragm.

In adjusting the reproducer to the recorded surface, the arm 30 should be set at such a height that the stylus will be given a slight rake to the recorded surface, as plainly shown in Fig. 9. This will permit the record to slide freely beneath the stylus without unduly scratching the same and cause the stylus to engage the record with

a sufficient pressure to insure the tracking of the stylus in the record groove. The record may then slide freely beneath the stylus, and the whole reproducer may swing slightly on the bolts or pins 40 to allow for any irregularity or unevenness or warp in the recorded surface.

In order that the stylus may not bear too heavily upon the record, the trumpet 11 may be provided with a suitable counter-balance-weight 59.

From the preceding description it will be plain that the whole construction is such that the trumpet, diaphragm, rings and stylus attached thereto may be swung upwardly about the bolts or pin 34 as a pivot for the purpose of replacing the stylus or for throwing the whole device into an inoperative position, as indicated in dotted lines in Fig. 9.

In operation it will be apparent that when the record is given a rotary movement from the turn-table 20 and the stylus 54 engages the record 21, the whole reproducer will swing about the stem or pintle 31 as a pivot allowing the needle or stylus 54 to track across the record and the stylus will be caused to assume the correct angle to the recorded surface by the adjustment of the step 32 against which the stem or pintle 31 abuts, and further, that the stylus will be prevented from bearing too heavily upon the record by the counter-weight 59 attached to the upper end of the trumpet 11.

In all the forms which I have above described, it will be seen that the diaphragm is constructed upon the same principle, and that it is mounted in substantially the same manner, and that any suitable manner of securing the stylus to the center of the diaphragm may be employed, and while I have shown a small trumpet 11 in connection with the constructions which I have illustrated, it is to be understood that the trumpet may be entirely dispensed with if desired, the function being to give direction to the sound waves rather than to increase the volume of the sound reproduced by the diaphragm.

Having thus described my invention, what I claim and desire to protect by Letters Patent of the United States, is:—

1. The method of making a diaphragm which consists in plaiting a strip of suitable material, joining the ends of the plaited material and bringing the same to a circular shape to form a diaphragm in which each of the plaits forms an element subjected to torsional tension.

2. The method of making a diaphragm which consists in plaiting a strip of flexible material, joining the ends of the plaited material and subjecting each of the plaits to a torsional tension.

3. The method of making a diaphragm which consists in reversely folding a strip of flexible material into a series of plaits, removing a corner of each of said strips, bringing the ends of said plaited material together and forming the same into a substantially circular shape having radial salient and reëntrant angles.

4. The method of making a diaphragm which consists in reversely folding a strip of flexible material, twisting the folded sheet into substantially circular shape and rigidly holding the edges of the diaphragm so formed in a single plane.

5. The method of forming a diaphragm, which consists in plaiting a substantially rectangular strip of material, removing a corner of each plait on one side of the strip, uniting the ends of the strip and forming the said material into a substantially circular diaphragm, each of the plaits forming an element of the diaphragm with its edge at the center of the diaphragm substantially parallel to the axis of the diaphragm and the edge of each plait at the periphery of the diaphragm being brought to substantially a single plane.

6. The method of forming a diaphragm, which consists in plaiting a substantially rectangular strip of material, uniting the ends of the strip and forming the said material into a substantially circular diaphragm, each of the plaits forming an element of the diaphragm with its edge at the center of the diaphragm substantially parallel to the axis of the diaphragm, the edge of each plait at the periphery of the diaphragm being brought to substantially a single plane, and securing an annular strip of stiffening to the edges of the elements adjacent the center of the diaphragm.

In witness whereof I have hereunto set my hand this fourth day of June, A. D. 1909.

LOUIS LUMIERE.

Witnesses:
L. N. Reddie,
A. J. Cooley.

Corrections in Letters Patent No. 986,477

It is hereby certified that in Letters Patent No. 986,477, granted March 14, 1911, upon the application of Louis Lumiere, of Lyon, France, for an improvement in "Acoustical Instruments," errors appear in the printed specification requiring correction as follows: Page 4, line 9, the word "steam" should read *stem*, and same page, line 100, the word "suitable" should read *suitably;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of April, A. D., 1911.

[SEAL.]

C. C. BILLINGS.

Acting Commissioner of Patents.

L. LUMIERE.

ACOUSTICAL INSTRUMENT.

APPLICATION FILED MAR. 26, 1910.

1,036,529.

Patented Aug. 20, 1912.

5 SHEETS—SHEET 1.

Fig. 1.

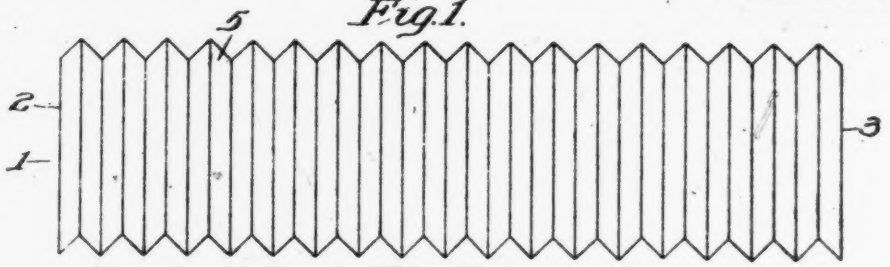


Fig. 2.

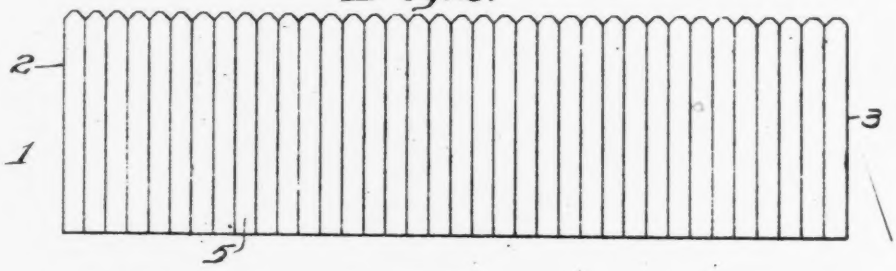


Fig. 3.

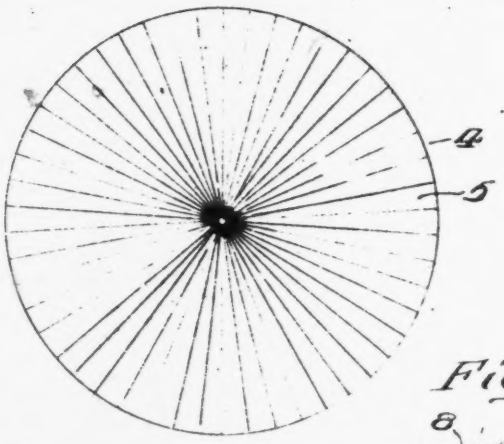


Fig. 4.

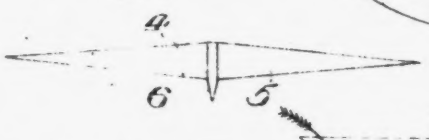
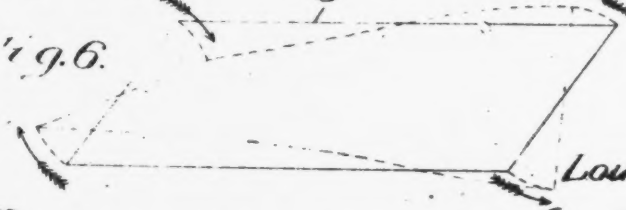


Fig. 5.

Fig. 6.



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APPLICATION FILED MAR. 26, 1910.

1,036,529.

Patented Aug. 20, 1912.

5 SHEETS—SHEET 2.

Fig. 7.

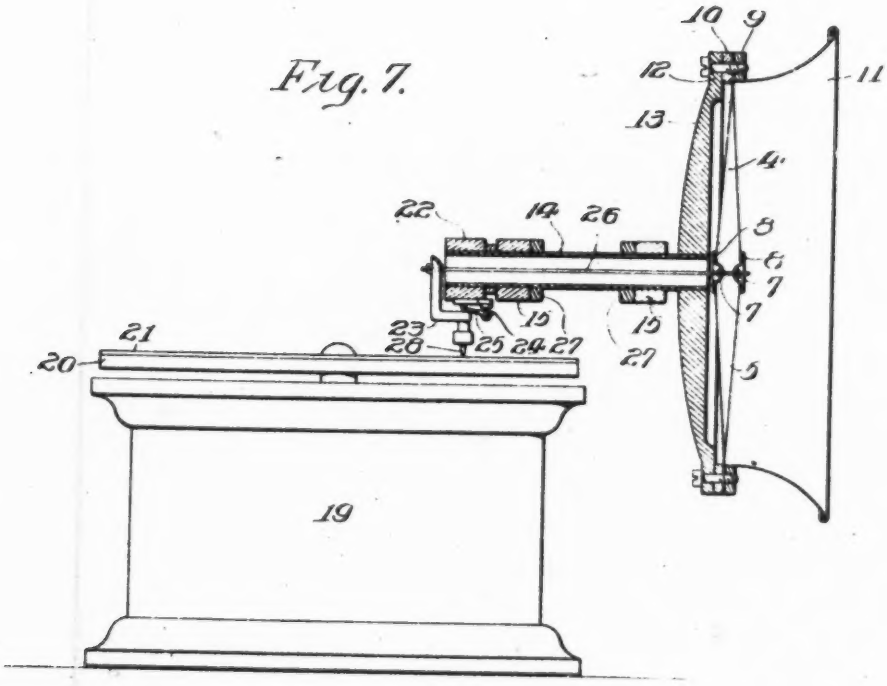
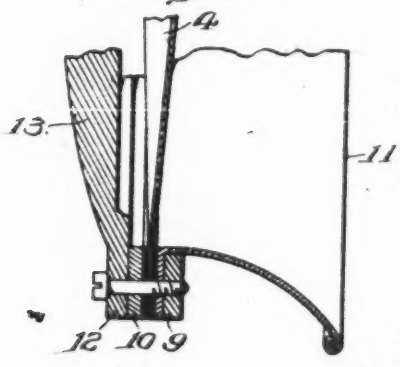


Fig. 7.a



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APPLICATION FILED MAR. 26, 1910.

1,036,529.

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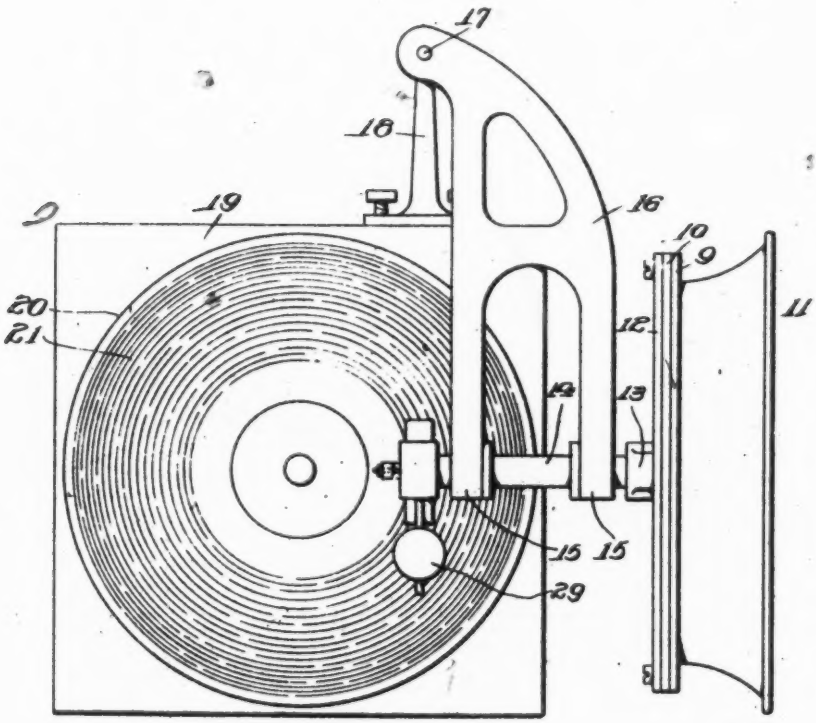
5 SHEETS—SHEET 3.

Fig. 8.



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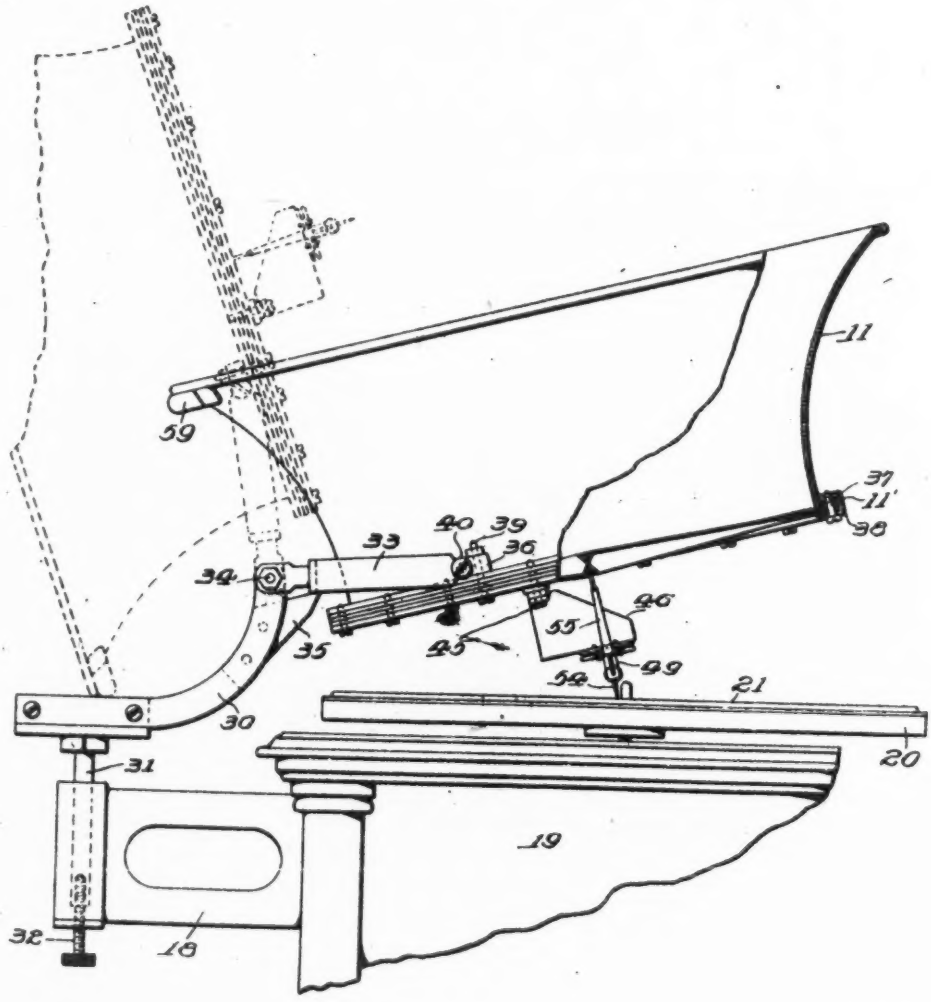
APPLICATION FILED MAR. 26, 1910.

1,036,529.

Patented Aug. 20, 1912.

5 SHEETS—SHEET 4.

Fig. 9.



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APPLICATION FILED MAR. 26, 1910.

1,036,529.

Patented Aug. 20, 1912.

5 SHEETS—SHEET 5

Fig. 10.

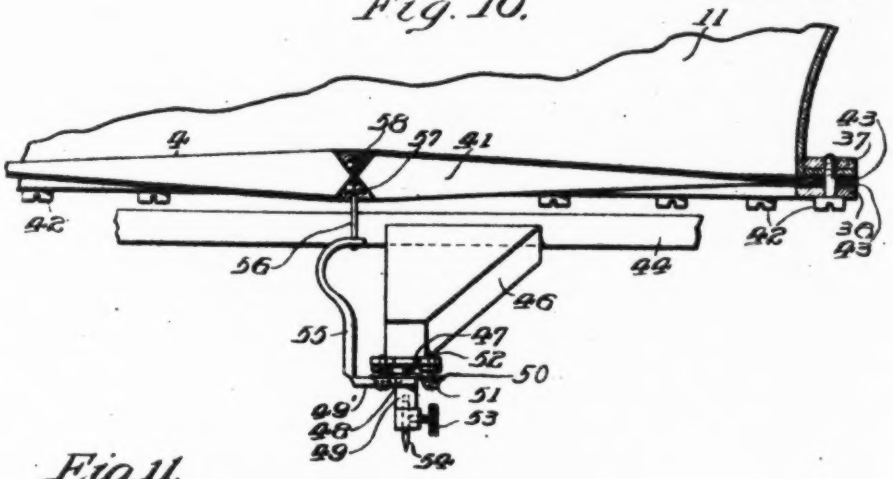
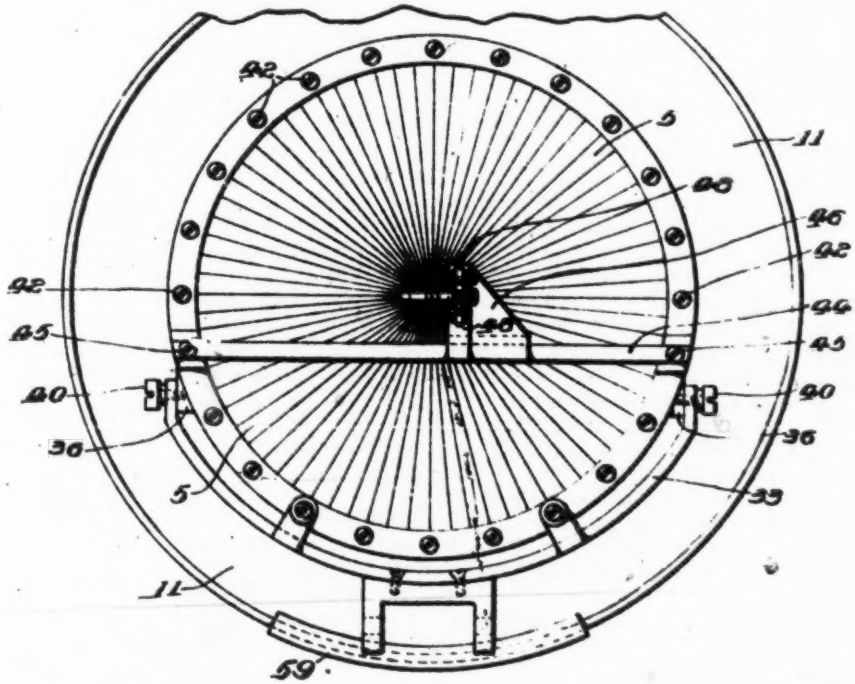


Fig. 11.



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UNITED STATES PATENT OFFICE.

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ACOUSTICAL INSTRUMENT.

1,036,529. Specification of Letters Patent. Patented Aug. 20, 1912.

Original application filed June 30, 1909, Serial No. 505,149. Divided and this application filed March 26, 1910. Serial No. 551,638.

To all whom it may concern:

Be it known that I, LOUIS LUMIERE, a citizen of the Republic of France, residing at Lyon, in the Republic of France, have invented certain new and useful Improvements in Acoustical Instruments, of which the following is a full, clear, and complete disclosure.

This invention relates to improvements in acoustical instruments, such as telephones, microphones, sound recording and reproducing machines, and musical instruments in general, and the present application is a division of an application filed by me June 30, 1909, Serial Number 505,149.

As applied to sound recording and reproducing apparatus, my invention relates more particularly to that part of the instrument which is generally known as the diaphragm, or the body which in the process of sound recording is thrown into vibration by the sound waves, and the vibrations of which are traced and recorded by means of a stylus in the original record, while in the process of reproduction the diaphragm, (as a general rule, the diaphragm of a separate machine) is thrown into corresponding vibrations by a stylus to which it is attached, being made to follow the undulations in the record.

My invention also relates to the sound box in which said diaphragm is mounted.

The object of my invention is to provide a diaphragm and a mounting therefor, by means of which sounds may be faithfully recorded and reproduced, which will be sensitive to sound waves and by the use of which the reproduction of sound will be improved and amplified.

Further objects of my invention are to increase the reproducing surface of a diaphragm, and, at the same time, to place the entire surface under a tension, (preferably torsional), to make it sensitive; to increase the active surface of a diaphragm of a certain given diameter; to increase the diameter of the diaphragm without making it liable to vibrate in parts, or to set up nodes or inactive portions in the diaphragm, or, in other words, to substantially increase the size of the diaphragm and, at the same time, have it vibrate throughout; to construct a diaphragm having a plurality of sound responsive elements, each of which is subjected to a molecular tension, and to subject each of a plurality of sound responsive elements to a molecular tension to increase the sensitiveness thereof and to cause them to vibrate as a whole.

Further objects of my invention will be found in the specification and claims below.

The invention consists in a diaphragm for acoustical instruments, having one or more freely resilient, sound responsive surfaces or elements, which have been brought into a condition of molecular stress, of an aggregate superficial area substantially larger than the surface of a plane disk of the same diameter, and in a recorder or reproducer in which said diaphragm is mounted.

It is found that the effect of bringing the surfaces of a vibrating body into a condition of molecular stress by torsion, is to reduce to a minimum the tendency of the vibrating body to form nodes during operation, so that the surface or surfaces of the diaphragm will vibrate as a whole and will not produce the disagreeable effect which is technically known as blasting or shattering.

One construction of diaphragm made according to this invention and the method of making it is illustrated in the accompanying drawings, in which:—

Figure 1 shows a folded strip of material from which the improved diaphragm may be made; Fig. 2 is a plan view of a modified form of folded strip of material from which a diaphragm may be made; Fig. 3 is a plan view of the diaphragm; Fig. 4 is a sectional elevation of the diaphragm; Fig. 5 is a sectional elevational view of a slightly modified form of diaphragm; Fig. 6 is a diagram to illustrate the way in which the surfaces or elements of the diaphragm are twisted; Fig. 7 is an elevation of a sound reproducing machine fitted with the diaphragm made in accordance with this invention and illustrates a convenient method of carrying the diaphragm and connecting it to the stylus bar; and Fig. 7ª is a sectional detail portion of Fig. 7. Fig. 8 is a plan view of the machine shown in Fig. 7; Fig. 9 is a side elevational view partly in section of a modified form of sound reproducing machine provided with my invention. Fig.

10 is an enlarged view, partly in section, of the diaphragm and stylus bar mounting shown in Fig. 9; and Fig. 11 is a bottom plan view of the reproducer shown in Fig. 9.

According to one method of carrying out this invention, a diaphragm is constructed so that it represents the form shown in Figs. 1, 3 and 4 of the accompanying drawings, in which the whole surface of the diaphragm on either side consists of a plurality of elements reversely flexed to form a fan-like series of radially disposed ridges and furrows, the ridges on one side of the diaphragm corresponding to the furrows on the other side of the diaphragm, and the furrows gradually widening out and becoming less deep as they approach the edge of the diaphragm until at its perimeter the diaphragm lies in one plane. The elements forming the sides of the ridges and furrows provide the desired freely resilient sound responsive surfaces. A diaphragm of this form may be obtained by folding or plaiting a substantially rectangular strip of paper 1, or other suitable material in the manner shown in Fig. 1. The length of the strip of material before folding should be substantially the length of the circumference of the diaphragm to be formed therefrom, and the width of the strip should be substantially equal to the radius of the said diaphragm. When the strip has been plaited or folded in the manner above described and shown, the ends 2 and 3 should be brought together and secured to each other in any suitable manner. At this stage of the process or method, the strip will present, roughly speaking, the appearance of a cylinder having fluted sides. This strip of material is then pressed down and forced to assume the form shown in Figs. 3 and 4, one edge of the strip being crimped together at the center, and the other edge forming the perimeter; the radial ridges and furrows, or plaits being closest together and of greatest depth at the center, and gradually opening out and flattening toward the edge where the diaphragm may be held in one plane between clamping rings, as shown in Figs. 7 to 11. In Fig. 3 the diaphragm is designated as 4 and the elements forming the plaits or ridges and furrows are designated by the numeral 5. The diaphragm 4 thus formed in the manner above described will be seen to have a surface formed wholly of a multiplicity of flexed sound responsive elements, reversely sloped or angled to each other, forming dihedral ridges. The surface of the diaphragm will consist of a surface comprising salient radial angled surfaces, and radial reëntrant angled surfaces. Any sector of the surface will have a fan-like formation. To the center of the diaphragm, is attached, in any suitable manner, the recording or reproducing stylus 6, as the case may be. As shown in Fig. 4, the diaphragm is for use with or for a record having an up and down, or vertical cut, since the diaphragm is directly provided with a stylus at its center. For making the attachment between the stylus and diaphragm, or between the connection between the stylus and the diaphragm, I prefer to bevel off the inner edge of the diaphragm as particularly shown in Figs. 2, 9 and 10. The stylus 6 may be secured directly to the inner edges of the elements of the diaphragm by being cemented or glued thereto in the manner shown in Fig. 4, or it may be secured in place by means of nuts 7, as will be more particularly described below, in connection with the form of apparatus shown in Figs. 5, 9 and 10. The stylus 6 may also be surrounded by rings of stiff paper 8, secured on either side of the diaphragm at the center thereof to give it additional rigidity at that point. I do not, however, limit myself to this form of connection. The effect of constructing the diaphragm in this manner, is that the whole diaphragm, *i. e.*, the surface of each element of each ridge and furrow is under molecular stress, produced by torsion, but the sides of the ridges and furrows are twisted out of the plane in which they lie at the center of the diaphragm into a plane, practically at right angles thereto, at the circumference of the diaphragm. I have further found that in a diaphragm produced by this means, the tendency of the vibrating body to form nodes during operation is reduced to a minimum. The surface of each of the elements composing this diaphragm being helicoidal, and since each point in the vibrating body, as it moves, follows a direction normal to the tangential plane at this point the result is that the direction of movement is different for each point that has to be considered so that the formation of nodes is practically impossible. It is obvious, of course, that the same condition of molecular stress would be produced upon twisting a sheet of material which naturally possessed a helicoidal, or other than plane, form so as to take up a position in a true plane, or other helicoidal form of different pitch.

The diagram shown in Fig. 6, illustrates clearly the torsion which is applied to each of the multiple surfaces or elements of the diaphragm when the strip of material is made to take up the form shown in Figs. 3 and 4 from the form shown in Fig. 1. In this diagram 5′ represents a thin flat sheet of elastic material, such as is formed by each of the several folds or plaitings of the strip shown in Figs. 1 and 2. If the two ends of this sheet are turned in opposite directions, as indicated by the arrows, and is made to take up the position shown in dotted lines, it is found that a very resilient body is

formed, which is capable of vibrating more readily, and is more sensitive, *i. e.*, more sound responsive in its new position than it was before. This is probably due to the molecular stress which is imparted to it by this twisting action.

It will be clear that each of the surfaces or folds 5, of the diaphragm illustrated in Figs. 3 and 4 is in the same condition of molecular stress, as the sheet 5′ in Fig. 6.

The width of the folds 5, relative to the breadth of the strip in which they are made, may vary; but I have found a convenient proportion to adopt when making the diaphragm of paper is about 10 to 1, so that each fold of the strip is 10 times as long as wide.

I have found that in a diaphragm having multiple resilient surfaces such as that above described, a greatly improved reproduction can be obtained. Moreover, a diaphragm constructed in the manner above described can be usefully made of considerably greater diameter than has heretofore been possible. Experience has seemed to prove that a plane diaphragm of mica, or other material, such as is used at the present day, if made of more than about three-and-a-half inches in diameter, loses in quality of reproduction, the reproduction becoming less musical and there being a liability to what there is technically known as "shattering," due probably to the diaphragm not vibrating as a whole, *i. e.*, to the setting up of nodes in the diaphragm. I have found, however, that I am able to make a diaphragm according to the present invention, as large as ten inches or more in diameter, without impairing the quality of the reproduction, and by means of this diaphragm, I at the same time, attain a much greater volume of sound than with the smaller diaphragm. This amplification of the sound, I believe to be due, not only to the increased diameter of the diaphragm, but also to the increased surface area of the diaphragm produced in the construction above described, by the plaitings or crimpings or folds in the material of the diaphragm; this appears to have the effect of putting into motion a greater volume of air and so increasing the volume of sound.

A diaphragm having freely resilient sound responsive surfaces brought into a condition of molecular stress, preferably by torsion; and also of an aggregate area substantially larger than a plane disk of the same diameter may of course be produced in other ways than that above described. I have found, however, that the above described method is a convenient one for making the diaphragm.

The advantage arising from the use of a diaphragm constructed as above described, is that the volume of sound produced is sufficient to enable me to dispense with the usual amplifying horn, and in this way, much of the metallic and hollow character usually associated with talking machine reproductions is eliminated.

Diaphragms may be made according to this invention, of any suitable elastic material, such as paper, (which may be varnished if desired), card, celluloid, metal, or the like, and the surface, or surfaces, of the diaphragm, or elements composing the vibrating body, may be put under tension by any suitable means.

One means of mounting the stylus bar and diaphragm in an operative position particularly for use with a record having a record of sound in the form of a groove having lateral undulations in the walls thereof is shown in Figs. 7 and 8. In this case, the diaphragm 4 is held at the edges by clamping rings 9 and 10, and, to the front ring 9, may be secured a small trumpet 11 for directing the sound waves. The clamping ring 10 is fixed to a suitable backing ring 12, having radial arms 13 by which the same is carried by a tube 14 which is capable of turning freely in the bearings 15—15, of the swinging arm 16, pivoted at 17 upon a rigid bracket 18, fixed to the cabinet 19. The cabinet 19 is provided with a suitable mechanism for rotating the turntable 20 upon which a record 21 is carried in the usual manner. The tube 14 is provided at one end with a mounting 22 freely rotatable upon said tube 14, but prevented in any suitable manner, from longitudinal movement upon the tube 14. This mounting 22 carries a stylus bar 23 which may be mounted thereon in any suitable manner, as by being pivoted on the knife edges 24, and retained on said knife edge bearings by a spring 25, in the usual manner. The upper end of the stylus bar 23 is connected by a rod 26 with the diaphragm 5, the rod 26 being connected or attached to the diaphragm by nuts 7 in the manner shown in Fig. 5. In this construction as shown in Figs. 7 and 8, the diaphragm is preferably made from a sheet of material such as is shown in Fig. 2 of the drawings so as to provide a suitable recess on each side of the diaphragm, in which the nuts 7 are seated. These nuts may be further cemented or otherwise secured to the diaphragm. In the said figures the diaphragm is also shown as being provided with a stiffening ring 8 at the center of the diaphragm and surrounding the stylus bar connection 26. Suitable nuts or collars 27 may be employed for holding the tube 14 from lengthwise movement in the bearings 15.

As the stylus 28 follows the record groove, the arm 16 will swing across the record on the pivot 17, and the mounting 22, carrying the stylus bar 23, will oscillate around the

tube 14 with any unevenness in the rotation of the record. A suitable weight 29 may be attached to the mounting 22, to cause the stylus to engage the record with the requisite amount of pressure.

In Figs. 9, 10 and 11, I have illustrated a further modification of the way in which my diaphragm may be used in connection with a sound reproducing machine. In said figures, the record 21 is supported upon and rotated by a turn-table 20 driven by any suitable motor within the casing 19, and the cabinet is provided with a bracket 18 similar to the arrangement above described in connection with Figs. 7 and 8. An arm 30 is mounted upon a stem or pintle 31 to swing on said bracket in a plane substantially parallel with the plane of the record 21. The bracket 18 may be provided with a vertically adjustable stop 32 for the end of the stem 31, which, in the form illustrated in Fig. 9, consists of a screw threaded into the bracket 18, and against which the end of the stem or pintle 31 rests. By this means, the arm 30 may be raised or lowered to adjust the parts carried thereby with respect to the record 21 on the turn-table 20, to set the stylus at the proper angle to the record surface. The free end of the arm 30 carries a yoke 33 pivoted to the said arm by a bolt or pin 34, so as to be capable of swinging in a plane substantially perpendicular to the plane of the record. The said arm 30 is provided with a stop 35, which prevents the yoke from swinging downwardly beyond a predetermined point. The outer ends of the yoke 33 are secured to lugs 36 bolted to the rings 37, 38, by bolts 39, passing through said rings and said lug. Screws 40, passing through the ends of the yoke 33 and into the lugs 36, form the pivots to permit the rings and the parts carried thereby, to oscillate thereon. The diaphragm 41 is of the kind which I have described above; that is to say, the diaphragm is formed by reversely folding a sheet of material to form plaits, each plait forming an element of the diaphragm, and each of these plaits or elements is subjected to a torsional tension or strain by the bringing of the folded or plaited sheet of material into a substantially circular form. In these Figs. 9 to 11, the diaphragm is shown practically as being formed from a sheet of material such as is shown in Fig. 2; that is to say, a strip in which each plait is cut away at its inner corners so as to form a recess on each side of the center of the diaphragm to permit of a convenient attachment of the stylus bar to the diaphragm.

As is plainly shown in Fig. 10, the diaphragm 41 is clamped between the rings 37 and 38, and securely held in that position by means of the screws 42 passing through the said rings and drawing them together. I prefer, however, to interpose, between the rings 37 and 38, and the diaphragm, thin rings 43—43 of a suitable non-metallic and preferably slightly elastic material, one on each side of the diaphragm. These rings 43, may be of fabric, or rubber, or fiber, or any other suitable material to prevent an actual contact between the diaphragm and the metallic rings 37 and 38, and to securely hold the periphery of the diaphragm in a single plane. A suitable small trumpet 11, may be also secured between the rings for the purpose of directing the sound waves. I have shown it plainly in Figs. 9 and 10 as composed of a slightly flaring substantially conical member having a flange 11′ clamped between the rings 37 and 38, the screws 42 passing therethrough. The periphery of the diaphragm 41 is clamped between the intermediate rings 43, and held thereby in a single plane as plainly shown in Fig. 10.

The bottom of the reproducer is provided with a suitable support for the stylus bar, said support comprising a bar 44 secured to the ring 38 by screws 45, or in any other suitable manner. The said bar 44 may carry a block 46 rigidly secured thereto and upon the lower side of said block, I mount the stylus bar. Any suitable mounting for the stylus bar may be employed, but in the said modification illustrated in Figs. 9 to 11, I have shown the block 46 as provided with a pair of alined knife edges 47 engaging suitable recesses and lateral extensions 48 of the stylus bar 49. Each lateral extension is provided with a spring 50, one end of which is attached to said extension 48, and the other end of which extends outwardly and is provided with a hole through which a screw 51 passes, the head of the screw engaging the end of said spring 50 and the screw being threaded in a suitably tapped plate 52 carried by the said block 46. In this way the stylus bar is yieldingly held upon the knife edges 47, but is free to oscillate upon them as bearings.

The lower end of the stylus bar is provided with a suitable set screw 53 for securing the stylus 54 in the socket therein. The stylus bar 49 may have a portion 49′ extending at an angle to the stylus carrying portion and it may then extend upwardly as at 55 to the point of attachment to the center of the diaphragm. I have shown the said upwardly extending portion 55 as being curved in order to make it slightly yielding, and the point between the portions 49′ and 55 as being materially weakened to enable the stylus bar to readily bend or spring or give slightly at this point to transform the vibratory movement of the stylus into a reciprocatory movement of the portion 55 which is directly attached to and consequently communicates its motion to the center of the diaphragm.

In adjusting the reproducer to the re-

corded surface, the arm 30 should be set at such a height that the stylus will be given a slight rake to the recorded surface, as plainly shown in Fig. 9. This will permit the record to slide freely beneath the stylus without unduly scratching the same and cause the stylus to engage the record with a sufficient pressure to insure the tracking of the stylus in the record groove. The record may then slide freely beneath the stylus, and the whole reproducer may swing slightly on the bolts or pins 40 to allow for any irregularity or unevenness or warp in the recorded surface.

In order that the stylus may not bear too heavily upon the record, the trumpet 11 may be provided with a suitable counterbalance-weight 59.

From the preceding description it will be plain that the whole construction is such that the trumpet, diaphragm, rings and stylus attached thereto may be swung upwardly about the bolts or pin 34 as a pivot for the purpose of replacing the stylus or for throwing the whole device into an inoperative position, as indicated in dotted lines in Fig. 9.

In operation it will be apparent that when the record is given a rotary movement from the turn-table 20 and the stylus 54 engages the record 21, the whole reproducer will swing about the stem or pintle 31 as a pivot allowing the needle or stylus 54 to track across the record and the stylus will be caused to assume the correct angle to the recorded surface by the adjustment of the step 32 against which the stem or pintle 31 abuts, and further, that the stylus will be prevented from bearing too heavily upon the record by the counter-weight 59 attached to the upper end of the trumpet 11.

In all the forms which I have above described, it will be seen that the diaphragm is constructed upon the same principle, and that it is mounted in substantially the same way, and that any suitable manner of securing the stylus to the center of the diaphragm may be employed, and while I have shown a small trumpet 11 in connection with the constructions which I have illustrated, it is to be understood that the trumpet may be entirely dispensed with if desired, the function being to give direction to the sound waves rather than to increase the volume of the sound reproduced by the diaphragm.

Having thus described my invention, what I claim and desire to protect by Letters Patent of the United States, is:—

1. A phonic diaphragm having a plurality of reversely flexed sound-responsive elements, each of said elements being held distorted from a normal shape under a torsional stress and tending to return to said normal shape.

2. In a sound box, the combination of a diaphragm composed of a plurality of radial sound-responsive elements, tending to assume a position coincident with a plane surface, and means to hold said elements in a flexed position.

3. A phonic diaphragm having a plurality of radial flexed sound-responsive elements, each element held under a torsional stress due to its flexed condition and tending to return to an unflexed condition.

4. A phonic diaphragm, having its entire surface composed of adjacent like elements arranged to form both salient and reëntrant angles, said angles forming alternate radial ridges and grooves, each of said elements being held distorted from a normal condition by a torsional stress and tending to return to said normal condition.

5. In a sound box, the combination of a diaphragm, having a plurality of radial sound-responsive elements tending to assume a position coincident with a plane surface, and means to hold said elements in a flexed position, with the outer ends of said flexed elements in a single plane.

6. A phonic diaphragm, having a plurality of sound-responsive elements, the angle between adjacent pairs of which progressively varies.

7. A phonic diaphragm including a plurality of like elements, each element being arranged between and inclined with respect to adjacent elements, each element being held under a torsional stress, and said elements tending to assume positions coincident with a common plane.

8. A phonic diaphragm, comprising a plurality of helical sound-responsive elements, which tend to form a common plane surface.

9. A phonic diaphragm, having a plurality of torsioned elements radially disposed, said elements tending to assume positions coincident with a common plane.

10. A circular phonic diaphragm, having a plurality of elements, the slope of which transverse to the radius varies continuously from a maximum at the center of the diaphragm to a minimum at the periphery.

11. A phonic diaphragm, having a plurality of elements of transverse slope, varying progressively along a radius.

12. A phonic diaphragm having a plurality of like torsioned elements which tend to return to a normal configuration.

13. A phonic diaphragm, formed of a plurality of sound-responsive elements, each of which is distorted under tension intermediate of its peripheral portions by the relationship of adjacent elements, and positive means for restraining the peripheral portions, said elements tending to return to a normal configuration.

14. In a sound recording or reproducing machine, a diaphragm composed of a plurality of elements, each of which is normally

subjected to torsional stress while in inoperative position, a stylus operatively connected to said diaphragm, and means to hold the edges of said diaphragm in substantially a single plane.

15. In a sound recorder or reproducer, a diaphragm composed of a plurality of elements, each of which is subjected to a torsional stress, the inner edge of each element being substantially parallel to the axis of the diaphragm.

16. In a sound recorder or reproducer, a diaphragm composed of a plurality of elements, each of which is subjected to a torsional stress, the inner edge of each element being substantially parallel to the axis of the diaphragm, and the corners of each element at the center of the diaphragm being beveled to form a recess at the center of the diaphragm.

17. In a sound recorder or reproducer, a diaphragm composed of a plurality of elements radially arranged, the inner edge of each element being substantially parallel to the axis of the diaphragm, and the outer edge of each element being substantially in a plane normal to the axis of said diaphragm.

18. In a sound recorder or reproducer, a diaphragm composed of a plurality of elements, the inner edge of each element being substantially parallel to the axis of the diaphragm, and means to hold the outer edge of each element in a single plane.

19. In a sound recorder or reproducer, a diaphragm composed of a plurality of helical elements radiating from the center of the diaphragm, and a stiffening ring secured to the outside edges of said elements.

20. In a sound recorder or reproducer, a diaphragm composed of a plurality of elements, each of which is distorted by a torsional stress and tends to return to a normal configuration, and clamping rings on each side of the peripheral edge of the diaphragm holding said edge in a single plane.

21. A phonic diaphragm comprising a body portion of substantially uniform thickness of material and arranged substantially in the form of a double cone.

22. A phonic diaphragm, comprising a body portion consisting of a single thickness of material and arranged substantially in the form of a double cone, having a substantially flat flexible rim and oppositely disposed radial plaits, tapering outwardly in depth from the center of said body portion.

23. A phonic diaphragm comprising a body portion consisting of a single thickness of material, having a substantially circular rim arranged in a single plane, said body portion being provided with radial plaits tapering outwardly in depth from the central portion of the diaphragm, said plaits having their alternate angles upon opposite sides of said plane and arranged in substantially balanced or symmetrical relationship thereto.

24. The combination with a phonic diaphragm of means normally holding said diaphragm, when in inoperative position, under a torsional stress.

25. A phonic diaphragm having a portion normally held, when in inoperative position, under a torsional stress and tending to return to its original state.

26. In a sound box, the combination with an annular support, of a diaphragm carried thereby, a bar secured to opposite portions of said support, a block rigidly secured to said bar, a stylus bar phonetically connected to said diaphragm and provided with oppositely disposed lateral extensions, alined knife edges between said extensions and said block and yielding means for holding said bar in position with respect to said block.

27. In a sound box, the combination with an annular support, of a diaphragm carried thereby, a bar secured to opposite portions of said support, a block rigidly secured to said bar, a stylus bar phonetically connected to said diaphragm and provided with oppositely disposed lateral extensions, alined knife edges between said extensions and said block, and yielding means for holding said bar in position with respect to said block, said yielding means comprising a spring between each of said extensions and said block.

28. In a sound box, the combination with a diaphragm, of a stylus bar comprising an inner portion phonetically connected to said diaphragm, and a comparatively rigid outer portion mounted to oscillate about a fixed axis and forming a continuation of, and extending substantially at a right angle with, said inner portion, said bar having a flexible reduced portion connecting and forming a hinge between said inner and outer portions at the vertex of said angle, and the oscillation of said outer portion producing a longitudinal reciprocation of said inner portion, said flexible portions being connected only to said inner and outer portions.

29. In a sound box, the combination with a diaphragm, of a stylus bar comprising an inner portion phonetically connected to said diaphragm, and a comparatively rigid outer portion mounted to oscillate about a fixed axis and forming a continuation of, and extending substantially at a right angle to, said inner portion, said bar having a flexible reduced portion connecting and forming a hinge between said inner and outer portions at the vertex of said angle, and the oscillation of said outer portion producing a longitudinal reciprocation of said inner portion, and said inner portion being partly in the form of a yielding loop to permit the effective length of said inner portion to be varied slightly

by the oscillation of said outer portion, said flexible portions being connected only to said inner and outer portions.

30. In a sound box, the combination with a support, of a diaphragm carried thereby, and a stylus bar, said stylus bar including a comparatively rigid portion mounted to oscillate on said support, and a connecting portion between said first mentioned portion and said diaphragm, said portions being joined by a flexible reduced portion forming a hinge between and connected only to said first mentioned portions, and the oscillation of said first mentioned portion resulting in the longitudinal reciprocation of said connecting portion.

31. A phonic diaphragm having a portion normally distorted under a twisting stress while in an inoperative position, and tending to return to its original form.

In witness whereof I have hereunto set my hand this 11th day of March, A. D. 1910.

LOUIS LUMIERE.

Witnesses:

PAUL H. CRAM.

SEPTIMUS BRACHER.

DEFENDANT'S EXHIBIT NO. 11-F.

509

J. C. ENGLISH.

SOUND BOX FOR TALKING MACHINES.

APPLICATION FILED OCT. 31, 1910.

1,064,062.

Patented June 10, 1913

Fig. 1.

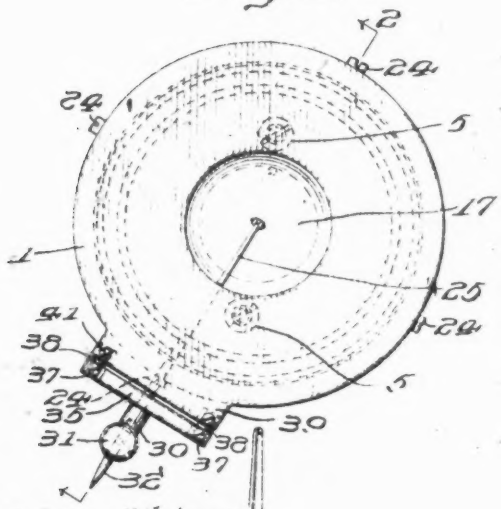

Fig. 2.

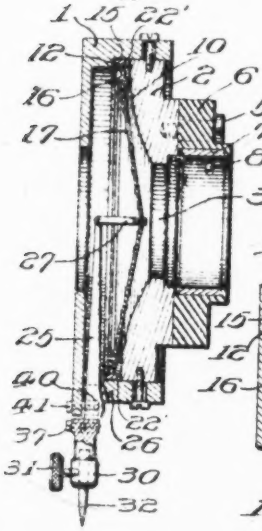

Fig. 4.

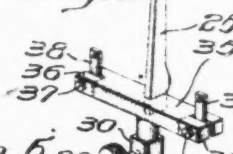

Fig. 3.

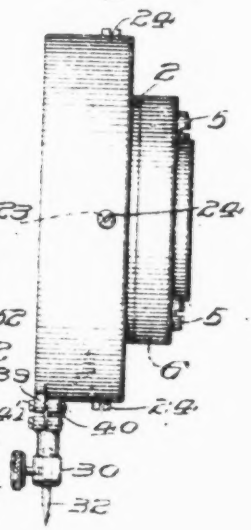

Fig. 5.

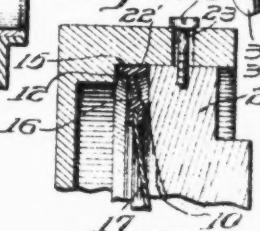

Fig. 6.

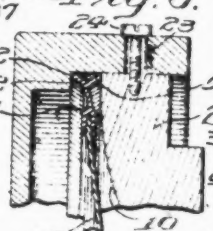

Fig. 7.

Fig. 8.

WITNESSES

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510

UNITED STATES PATENT OFFICE.

JOHN C. ENGLISH, OF CAMDEN, NEW JERSEY, ASSIGNOR TO VICTOR TALKING MACHINE COMPANY, A CORPORATION OF NEW JERSEY.

SOUND-BOX FOR TALKING-MACHINES.

1,064,062. Specification of Letters Patent. Patented June 10, 1913.

Application filed October 31, 1910. Serial No. 589,246.

To all whom it may concern:

Be it known that I, JOHN C. ENGLISH, a citizen of the United States, and a resident of the city of Camden, county of Camden, and State of New Jersey, have invented certain new and useful Improvements in Sound-Boxes for Talking-Machines, of which the following is a full, clear, and exact disclosure.

The main objects of this invention are, to provide an improved sound box of simple, compact and durable construction that will record or reproduce sounds with great accuracy and efficiency; to provide in a sound box, an improved casing, an improved diaphragm, and an improved stylus bar and mounting therefor; and to provide other improvements as will appear hereinafter.

It has been contended that in sound boxes in which a thin flexible diaphragm is used and in which the sound vibrations are produced or recorded by flexing the diaphragm, the diaphragm acts like a reed and responds sympathetically to certain tones in a manner that produces undesirable results. It has also been contended that such a diaphragm is comparatively difficult to vibrate and does not act with sufficient sensitiveness to produce or to record delicate over-tones. In this invention these defects which it has been contended are incident to the recording or reproduction of sound by the flexing of a diaphragm, are obviated by utilizing, instead of a flexible diaphragm, a light substantially inflexible diaphragm and an improved mounting therefor whereby the diaphragm is permitted to vibrate as a whole without being flexed.

In the accompanying drawings, Figure 1 is a front elevation of a sound box constructed in accordance with this invention; Fig. 2 a transverse section on the line 2—2 of Fig. 1; Fig. 3 a side elevation of the same; Fig. 4 a perspective of a detail of the same; Fig. 5 a fragmentary enlargement of a portion of Fig. 2; Fig. 6 a view similar to Fig. 5 but showing a modified form of this invention; Fig. 7 an enlarged fragmentary diametrical section of the diaphragm and mounting or supporting ring shown in Figs. 1, 2 and 5 as they appear before being placed in position in the sound box; and Fig. 8 is a view similar to Fig. 7, showing in a similar way the diaphragm and modified form of mounting therefor which are shown in operative position in Fig. 6.

Referring to the drawings, one embodiment of this invention comprises a cylindrical sound box casing or support composed of two main portions,—a cylindrical cup shaped front plate 1 and a back plate 2 telescoping into the front plate and provided with a circular central aperture 3 for the passage of sound waves.

Secured to the rear face of the back plate 2, coaxial therewith, by means of screw 5, is a yielding tubular extension 6 provided with a non-yielding lining 7 and an inwardly projecting stop 8, whereby the sound box may be telescoped over the usual tubular tone-arm or sound conveyer (not shown).

The inner surface 10 of the back plate 2 is preferably convexly curved flaring inwardly from the central aperture 3 to the outer periphery of the plate. The inner surface of the front plate 1 of the casing is preferably in the form of a stepped cylinder, providing an annular shoulder 12 facing rearwardly and spaced from the opposite inner surface of the back plate 2, forming therewith an annular recess 15 in which snugly fits a yielding gasket or mounting 16, in which is supported a diaphragm 17.

The gasket 16 is continuous or closed in structure, is preferably made of rubber or other suitable solid resilient or yielding material, and is preferably substantially T-shaped in cross section, comprising a base 18 substantially equal in width to the width of the recess 15, and having a cylindrical outer surface 19 slightly greater in diameter than the cylindrical inner surface of the recess 15. The inner surface of the base 18 is preferably convex in cross section and in the form of two oppositely disposed inwardly converging conical surfaces 20, which meet in a centrally arranged normally flat annular web 21 which forms a reduced intermediate portion of the gasket. This web 21 is integral with the base 18 and extremely thin and flexible. The inner portion of the web 21 terminates in an annular binder or holder

integral with and thicker than the web and is provided upon its inner edge with a centrally arranged annular cylindrical grooved recess 22, in which snugly fits the marginal portion of the diaphragm 17. The gasket may be held in position by means of wax 22′ or other similar material applied between the base of the gasket and the inner cylindrical surface of the front plate 1.

The diaphragm 17 is preferably made of paper or any other light material, and when made of paper or other similar porous material may be impregnated with resin or any other substance or composition to make the diaphragm moisture-proof. The diaphragm is of substantially uniform thickness throughout its entire extent, and with the exception of its marginal portion, is preferably dished or conical in shape, converging rearwardly axially with the sound box casing. The marginal portion of the diaphragm is preferably in the form of a flat annulus, arranged in a plane perpendicular to the longitudinal axis of the sound box.

As the diameter of the gasket 16 is slightly larger than the internal diameter of the recess 15, in which it is held, the gasket will be held under a state of compression when the diaphragm and gasket are in operative position in the casing, and the thin portion of the web 21 will be slightly distorted laterally, as shown in Fig. 2 and enlarged in Fig. 5, from its normally flat condition. The diaphragm is thus held when in operative position under a slight tension or compression against the periphery 17′ thereof by the gasket acting radially against the peripheral edge of the diaphragm and it may here be stated that so far as this application is concerned the expressions "periphery" or "peripheral portion" or "peripheral edge" refer to the outer edge of the diaphragm, that is to say, that portion of the diaphragm between the plane surfaces of the opposite sides of the marginal portion of the diaphragm.

To hold the back plate 2 in position and to permit of the adjustment of the back plate toward and away from the gasket 16, a series of oblong apertures 23 are provided through the cylindrical rim of the front plate, and a headed screw 24 extends loosely through each of these apertures and is threaded into the back plate. By this construction the pressing of the back upon the base of the gasket may be varied to increase or diminish the pressure of the gasket against the peripheral edge of the diaphragm.

For communicating vibrations corresponding to sound waves to or from the diaphragm, a stylus bar 25 is mounted to oscillate upon the front plate of the sound box casing, one end of the bar being within the casing axially in front of the diaphragm, and the bar extending radially outwardly through an aperture 26 provided therefor in the casing. The inner end of the stylus bar is pivotally connected to the outer end of a light but rigid connecting rod 27, the inner end of which is phonetically connected in any suitable manner to the central portion of the diaphragm, the outer end of the connecting rod being preferably bifurcated to receive the inner end of the stylus bar. The outer end of the stylus bar projects outwardly from the sound box casing and is provided with the usual stylus socket 30 and set screw 31 for holding a stylus 32 in place.

For supporting the stylus bar to oscillate upon a substantially fixed axis with respect to the sound box casing, the bar is provided outside of the casing with a cross-piece 35, rigid therewith, and projecting in opposite directions therefrom. Each end of this cross-piece 35 is recessed to receive a clamping plate 36, which is adjustably connected to the cross-piece by means of a headed screw 37, which extends loosely through the clamping plate and an aperture in one end of a flexible connector 38 and is threaded into the cross-piece 35.

Each of the two flexible connectors, or spaced yielding supports 38 is preferably made of thin tempered steel, but may be made of copper, fabric or other non-resilient material. Each connector 38 extends inwardly from the cross-piece 35, being clamped rigidly at its outer end between the cross-piece 35 and the clamping plates 36 by means of the screw 37. The inner end of each flexible connector 38 is similarly clamped against the rear surface of an extension 39, integral or rigid with the front portion of the sound box casing, by means of a clamping plate 40 and a screw 41. The flexible connectors 38 are thus arranged parallel to each other and in a plane substantially perpendicular to the longitudinal axis of the sound box casing.

The space between the extension 39 of the casing and the cross-piece 35 of the stylus bar is preferably only sufficient to permit of the necessary oscillation of the bar, and the bar is thus restrained to swing upon a substantially fixed axis, perpendicular to the bar and parallel to the plane of the marginal portion of the diaphragm.

In the modified form of this invention shown in Figs. 6 and 8, the sound box casing and the diaphragm 17 are constructed as hereinbefore described and the gasket 51 is substantially identical with the gasket 16, hereinbefore described except that the marginal portion of base of this gasket is bifurcated and in the form of two outwardly diverging portions 52. The outer diameter of the bifurcated base of this gasket is nor-

mally substantially the same as the inner diameter of the annular groove 15 in which it rests.

When the gasket 51 is in its operative position the free edges of the two portions 52 of the base of the gasket are clamped toward each other between the shoulder 12 of the front plate 1 and the inner surface of the back plate 2, so as to compress the gasket radially against the peripheral edge of the diaphragm 17. The thin web-like portion of the gasket is slightly distorted laterally from its normally flat plane by this compression.

The stylus bar and its mounting and other features of this modified construction may be the same as shown and hereinbefore described.

In the operation of this device, owing to the extreme thinness and flexible nature of the web forming the intermediate portion of the gasket, and to the extreme lightness and comparatively inflexible nature of the diaphragm, the diaphragm is extremely sensitive to respond to the vibration of the stylus bar in reproducing sound or to respond to the action of the sound waves in recording sound and in either case therefore the diaphragm vibrates as a whole without any appreciable flexing and there is very little, if any, appreciable loss of efficiency due to the diaphragm or its mounting.

It is evident that in applying this invention various changes might be made in the constructions without departing from the spirit of this invention or the scope of the appended claims.

Having thus described this invention, I claim and desire to protect by Letters Patent of the United States:

1. In a sound box, the combination with a substantially inflexible conical diaphragm, of a yielding gasket supporting said diaphragm, said gasket being held under an initial pressure forcing said gasket against the peripheral edge of said diaphragm.

2. In a sound box, the combination with a circular diaphragm, of a yielding gasket supporting the same, said gasket comprising an annular base portion greater in internal diameter than the diameter of said diaphragm and surrounding said diaphragm in the plane of the marginal edge thereof, and comprising a relatively thin annular portion between said base portion and said diaphragm.

3. A gasket for a sound box comprising an annular base portion, and a relatively thin normally flat annular portion carried by said base portion And projecting toward the center of said base portion from the internal surface of said base portion.

4. A yielding gasket for a sound box, comprising a base portion, a relatively thin portion inclosed by and projecting inwardly from said base portion, and a holder extending inwardly from said relatively thin portion, and adapted to support the marginal portion of a diaphragm.

5. An annular yielding gasket for a sound box, comprising a base portion, a relatively thin portion projecting inwardly from said base portion, and a grooved holder extending inwardly from said relatively thin portion, and adapted to support the marginal portion of a diaphragm.

6. In a sound box, the combination with a diaphragm, of yielding means engaging the peripheral edge of said diaphragm, and adjustable means for compressing said yielding means to apply a yielding pressure upon said peripheral edge radially with respect to said diaphragm.

7. In a sound box, the combination with a yielding support, of a diaphragm having its marginal edge surrounded and engaged by said support, the diaphragm being of a size to place the yielding support under initial compression, and adjustable means acting on the yielding support to modify the state of compression of said support.

8. In a sound box, the combination with a diaphragm having a cupped central portion and a substantially flat rim, of a yielding gasket engaging said rim and held under an initial pressure, forcing said gasket radially against the peripheral edge of said rim.

9. In a sound box, the combination with a diaphragm, of a yielding gasket supporting said diaphragm, and bearing against the marginal edge thereof, said gasket comprising a yielding base portion having a internal diameter greater than the externa diameter of said diaphragm and arranged in the plane of the marginal edge of said diaphragm, and comprising a relatively thin yielding portion between said base portion and said diaphragm.

10. An annular yielding gasket for a sound box, said gasket comprising a yielding annular base portion, and a yielding annular portion thinner than and inclosed by said base portion, integral therewith and projecting inwardly from the internal surface of said base portion.

11. An annular yielding gasket for a sound box, comprising a yielding annular base portion, a normally flat annular web thinner than said base portion and integral with and projecting inwardly therefrom, and an internally grooved holder projecting inwardly from said web and integral therewith.

12. In a sound box, the combination with a diaphragm of a gasket surrounding said diaphragm and supporting the same, said gasket comprising a holder embracing the

opposite sides of the margin of said diaphragm, having a relatively thin web-like yielding portion integral with said holder and surrounding the same.

13. In a sound box, the combination with a diaphragm of a gasket surrounding said diaphragm and supporting the same, said gasket comprising a holder embracing the opposite sides of the margin of said diaphragm, having a relatively thin web-like yielding portion integral with said holder and surrounding the same, said gasket being in contact with the marginal edge of said diaphragm.

14. In a sound box, the combination with a diaphragm vibratory as a whole, without flexing, and in a direction transverse to its own plane, of a yielding gasket surrounding and supporting said diaphragm, said gasket being free to flex, and being held under an initial state of compression by said diaphragm.

15. In a sound box, the combination with a diaphragm vibratory as a whole, without flexing, and in a direction transverse to its own plane, of a yielding gasket surrounding and supporting said diaphragm, said gasket being free to flex, and being held under an initial state of compression by said diaphragm, said gasket reacting to compress said diaphragm radially.

16. In a sound box, the combination with a dished diaphragm of substantially uniform thickness throughout its full extent, of a yielding gasket surrounding and supporting said diaphragm, said gasket being free to flex and being held in an initial state of compression by said diaphragm.

17. In a sound box, the combination with a diaphragm of a yielding gasket free to flex and supporting said diaphragm in an initial state of compression, said diaphragm reacting to hold said gasket under an initial state of compression.

18. In a sound box, the combination with a diaphragm vibratory as a whole without flexing, and in a direction transverse to its own plane, of a yielding gasket supporting said diaphragm and holding the same in an initial state of compression, said diaphragm reacting to hold said gasket in an initial state of compression.

19. In a sound box, the combination with a diaphragm vibratory as a whole without flexing and in a direction transverse to its own plane, of a yielding gasket entirely supporting said diaphragm and holding the same in an initial state of compression, said diaphragm reacting to hold said gasket in an initial state of compression.

20. In a sound box, the combination with a substantially inflexible diaphragm vibratory as a whole in a direction transverse to its own plane, of a yielding gasket inclosing said diaphragm and contacting with the peripheral edge thereof and holding said diaphragm in an initial state of compression, said diaphragm reacting through its marginal edge to hold said gasket in an initial state of compression.

21. A gasket for a sound box, comprising a continuous base portion, and a relatively thin web portion carried and surrounded by said base portion.

22. A gasket for a sound box, comprising a continuous base portion and a relatively thin web portion carried by said base portion and projecting into the space inclosed by said base portion.

23. A gasket for a sound box, comprising a continuous yielding base portion, and a relatively thin yielding web portion surrounded and carried by said base portion.

24. A gasket for a sound box, comprising a continuous yielding base portion, and a relatively thin yielding web portion surrounded and carried by said base portion and wholly included in the space surrounded by said base portion.

25. In a sound box, the combination with a diaphragm, of yielding means engaging the peripheral edge of the diaphragm and confined peripherally, and adjustable means for compressing said yielding means laterally to apply yielding pressure on the diaphragm in the plane of said edge.

26. A gasket for a sound box comprising a base portion, and a relatively thin flat web portion carried by said base portion and projecting inwardly from the internal surface of said base portion.

27. In a sound box, the combination with a diaphragm, of a yielding support engaging the peripheral edge of the diaphragm, and adjustable means acting on said yielding support to cause the same to apply different yielding pressures on the peripheral edge of the diaphragm in a plane substantially normal to the axis of the diaphragm.

28. In a sound box, the combination with a diaphragm, of yielding means engaging the peripheral edge of the diaphragm, and adjustable means acting on said yielding means to produce varying pressures of said yielding means on the diaphragm, said yielding means exerting a pressure on the peripheral edge of said diaphragm independently of said adjustable means.

29. In a sound box, the combination of a substantially inflexible diaphragm, a flexible web member supporting said diaphragm by engagement with the peripheral portion thereof, and means for causing stress in said flexible member to act on the periphery of said diaphragm solely in a plane substantially normal to the axis of said diaphragm.

30. In a sound box, the combination of a substantially inflexible diaphragm, a yield-

ing member surrounding and supporting said diaphragm, and means acting on said yielding member to vary the stress of said yielding member with respect to said diaphragm, said yielding member exerting a pressure on the peripheral edge of said diaphragm independently of said adjustable means.

In witness whereof, I have hereunto set my hand this 27th day of October, A. D. 1910.

JOHN C. ENGLISH.

Witnesses:
CHARLES C. MOSS,
FRANK B. MIDDLETON, Jr.

DEFENDANT'S EXHIBIT NO. 11-G.

515

J. C. ENGLISH.

SOUND BOX,

APPLICATION FILED JAN. 23, 1912.

1,192,289. Patented July 25, 1916.

Fig. 1.

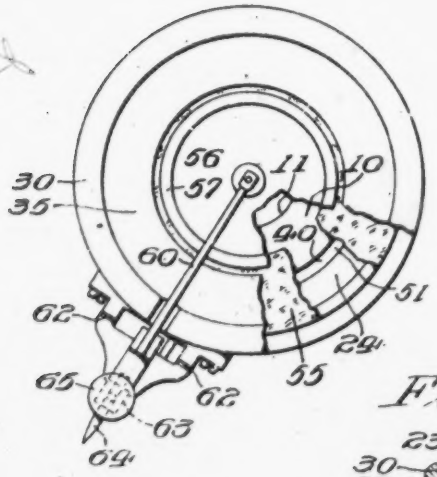


Fig. 2.

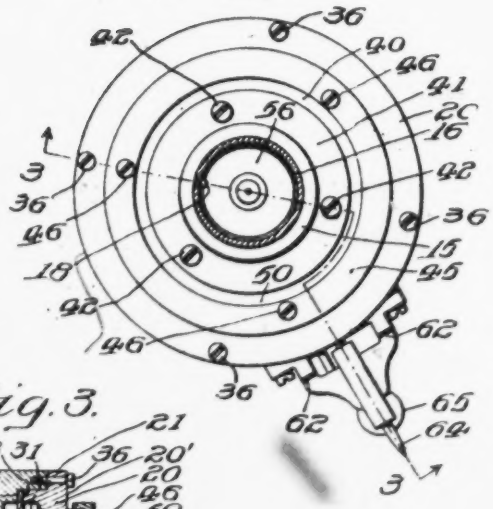


Fig. 3.

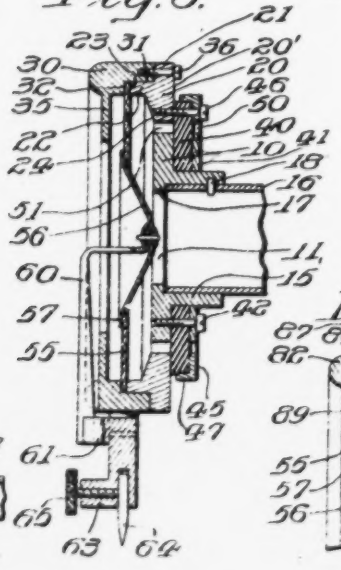


Fig. 4.

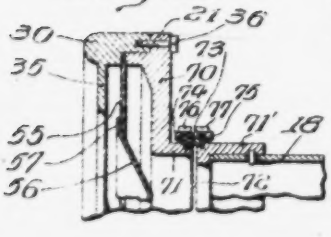
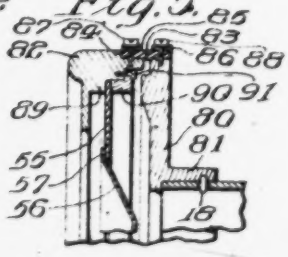


Fig. 5.



INVENTOR

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WITNESSES

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A. L. Gardner.

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ATTORNEY

UNITED STATES PATENT OFFICE.

JOHN C. ENGLISH, OF CAMDEN, NEW JERSEY, ASSIGNOR TO VICTOR TALKING MACHINE COMPANY, A CORPORATION OF NEW JERSEY.

SOUND-BOX.

1,192,289. Specification of Letters Patent. Patented July 25, 1916.

Application filed January 23, 1912. Serial No. 672,961.

To all whom it may concern:

Be it known that I, JOHN C. ENGLISH, a citizen of the United States, and a resident of the city of Camden, county of Camden, and State of New Jersey, have invented certain new and useful Improvements in Sound-Boxes, of which the following is a specification.

The main objects of this invention are to provide in a sound box for talking machines, adjustable means for supporting the major portion of the same; to provide in a sound box, an improved diaphragm and mounting therefor; and to provide other improvements as will appear hereinafter, the purpose as a whole being to provide a sound box that will be extremely efficient in operation.

In the accompanying drawings, Figure 1 is a fragmentary front elevation of a sound box constructed in accordance with this invention; Fig. 2 a rear elevation of the same; Fig. 3 a longitudinal section on line 3—3 of Fig. 2; and Figs. 4 and 5 are fragmentary longitudinal sections of two modified forms respectively of the same.

Referring to the drawings, one embodiment of this invention consists of a sound box comprising a casing, including a flat annular supporting plate or member 10, coaxial with the casing and forming a portion of the back thereof. This supporting plate 10 is preferably made of comparatively rigid material, such as brass or any other suitable metal. Surrounding the central opening 11 of this plate 10 and projecting rearwardly from the plate, and integral or rigid therewith, is a tubular extension 15, which is adapted to telescope over the open free end of the usual or any suitable hollow tone arm 16 or other support. The internal diameter of the tubular extension 15 is preferably somewhat greater than the diameter of the central opening 11 of the supporting plate 10, thus forming an internal annular shoulder 17 between the tubular extension 15 and the supporting plate 10, this shoulder being adapted to abut against the inner end of the hollow tone arm 16 to assist in holding the sound box in position upon the tone arm. The usual pin 18 projects inwardly from the tubular extension 15 rigid therewith, and is adapted to perform its usual function of engaging in a bayonet slot in the tone arm 16. The diameter of the opening 11 in the supporting plate and the internal diameter of the tone arm 16, are preferably made equal so that the inner surface of the tone arm 16 will be flush with the cylindrical wall of the opening 11.

Surrounding the supporting plate 10 coaxial therewith and slightly spaced therefrom, is an annular marginal member 20, also forming a portion of the back of the casing of the sound box, and preferably made of the same material as the supporting plate 10, or of any suitable comparatively rigid material. The rear surface 20′ of this marginal member 20, is preferably flat and normally flush with the rear surface of the supporting plate. This marginal member 20 is provided upon its outer margin with an outwardly projecting flat annular flange 21, integral and coaxial therewith, and arranged flush with the rear surface 20′ of the marginal member. The marginal member 20 projects forwardly from its flat annular flange 21 in the form of a cylindrical flange 22 having a flat annular forwardly facing end wall 23. From the cylindrical flange 22, the marginal member 20 tapers inwardly in thickness measured in a direction perpendicular to the rear surface 20′, and the inner face 24 of the member 20 is conical in form and coaxial with the tubular extension 15.

Telescoping snugly over the cylindrical flange 22 of the marginal member 20 is a hollow cylindrical cap 30, also preferably made of brass or other suitable comparatively rigid material. This cap 30 has a flat annular rear wall 31 normally abutting against the front face of the flange 21 of the marginal member 20, and is provided with an internal annular shoulder 32 normally spaced slightly in front of the end wall 23 of the flange 22 of the marginal member 20 and of equal dimensions. The front portion of the cap 30 is provided with an inwardly projecting flat thin annular flange 35, coaxial and integral or rigid therewith. The cap 30 is secured to the marginal member 20 by means of screws 36 extending through the flange 21 and threaded into the rear wall of the cap, or by any other suitable means.

For yieldingly supporting the marginal member 20 and cap 30 carried thereby, a flat yielding annulus 40 snugly surrounds the tubular extension 15 and is secured to the rear wall of the supporting plate 10 and also to the rear wall of the marginal member 20. This yielding annulus 40 is preferably made of felt, leather, paper, cork, rubber, or any other similar or suitable yielding material. It has been found that felt gives very good results in this connection. The annulus 40 is preferably clamped securely against the rear wall of the supporting plate 10 by means of a metal or other comparatively rigid annular washer 41, fitting snugly around the tubular extension 15, and clamped against the rear face of the annulus 40 by means of headed screws 42, extending loosely through the washer 41 and annulus 40 and threaded into the supporting plate 10. The annulus 40 is also preferably clamped securely against the rear wall of the marginal member 20 by means of a similar flat annular outer washer 45, surrounding and spaced from the inner washer 41 and clamped against the rear wall of the annulus 40 by means of headed screws 46 extending loosely through the washer and annulus and threaded into the marginal member 20. The screws 42 through the inner washer 41 are preferably arranged in staggered relation with respect to the screws 46 of the outer washer 45. This outer washer 45 is preferably provided with an inwardly projecting marginal cylindrical flange 47 which engages snugly over the outer marginal wall of the annulus 40, and the inner end wall of which is normally spaced slightly from the rear wall of the marginal member 20. This flange 47 serves to confine the annulus 40 within certain limits and also protects the margin of the annulus and improves the appearance of the sound box.

The annular space 50 between the inner and outer washers 41 and 45 is preferably opposite and substantially equal in area to the area of the space 51 between the supporting plate 10 and the marginal member 20, and these spaces are preferably only of sufficient width to permit of a desirable amount of yielding or flexing of the annulus 40 throughout the annular portion of the annulus included between these two annular spaces.

Any suitable diaphragm may be used in connection with the casing of this improved sound box, but in the present instance, an improved diaphragm, which has been made the basis of a separate application, is shown in this connection. This improved diaphragm comprises a thin flat outer annular portion 55, made of cork or a composition of cork, or made of other subereous or suitable yielding material, having little, if any tendency, to set up local vibrations. Surrounded by the flat annular portion 55 is a thin comparatively rigid cupped or conical portion 56, made of any suitable material, such as stiff paper, and arranged normally coaxial with the sound box casing, and having its convex side facing rearwardly. The marginal portion 57 of this conical portion 56 is preferably slightly flattened and overlaps the inner margin of the flat annular portion 55 and is secured thereto, preferably upon the front side thereof, by means of cement or glue, or in any other suitable manner.

The outer marginal portion of the diaphragm is clamped securely in position by and between the end wall 23 of the marginal member 20 and the internal shoulder 32 of the cap 30 of the sound box casing. The nature of the material forming the marginal portion of the diaphragm is such that when the diaphragm is thus clamped in position, it adheres to the walls between, and by which it is clamped and any possibility of leakage of the air around the outer margin of the diaphragm is thus avoided, and also any tendency of the diaphragm to rattle is avoided.

Connected to the central portion or apex of the conical portion 56 of the diaphragm is one end of a stylus bar 60, which projects outwardly from the conical portion in a direction substantially coaxial therewith to a point in front of the flange 35 of the cap 30, and then turns radially outwardly in a direction parallel to the flange 35 and spaced slightly in front thereof. The outer portion 61 of this stylus bar is offset rearwardly outside of the cap 30 and is mounted upon the cap 30 to oscillate in respect thereto by means of spaced yielding connections 62, these yielding connections being preferably arranged so that the axis of oscillation of the stylus bar is substantially in a plane with the flat annular portion 55 of the diaphragm. The stylus bar is provided with an enlarged outer end 63 adapted to hold the usual or any suitable stylus 64, which is held in place by the usual set screw 65.

From the foregoing description, it is evident that in the construction described, the sound box casing may be considered broadly as being composed of two independently movable rigid members, one of which, including the marginal member 20 and the cap 30, carries the diaphragm and cooperating stylus, and the other of which including the supporting plate 10 and its tubular extension 15, is adapted to be mounted upon the tone arm 16 or other suitable carrier, these two main portions of the sound box casing being connected by a yielding or hinge-like means which permits of the relative movement of the main portions of the casing, and also acting as a closure for the space between these portions. It is also evident

that the yielding annulus 40 may be placed under a greater or less initial tension by adjusting the screws 42 and 46 to vary the compression of the annulus and that this variation of the initial aperture or tension would correspondingly affect the yielding qualities of the annulus and the freedom of movement between the two main portions of the sound box casing, and give a corresponding modification in the volume and quality of reproduction. It is also evident that in the operation of this sound box, the central portion of the diaphragm will vibrate as a whole without flexing, and the surrounding portion will flex to permit of this vibration.

Instead of forming the back of the sound box casing as hereinbefore described, of two spaced annular members, one surrounding the other, the back of the sound box may be formed of a single piece as indicated at 70 in Fig. 4, and having a tubular extension 71, 71′ divided and spaced apart as at 72, the two portions 71 and 71′ of the tubular extension being yieldingly connected by a cylindrical ring 73 of yielding material, such as felt or rubber, etc., snugly surrounding the tubular extension and clamped to the two portions of the extension by means of comparatively rigid flanged rings 74 and 75 held in place by screws 76 and 77 extending through the rings and threaded into the two portions 71 and 71′ respectively of the tubular extension.

A further modification of this invention consists in forming the back of the sound box casing and its tubular extension in one part, as indicated at 80 and 81 respectively, and having an annular cap 82 spaced slightly in front of the back 80 and yieldingly connected thereto by means of a yielding cylindrical ring 83 surrounding the back 80 and engaging in an annular recess 84 provided therefor in the outer surface of the cap 82, the yielding ring 83 being clamped in position against the cap 82 and the back 80 by means of the rings 85 and 86 surrounding the yielding ring and held in place by screws 87 and 88 respectively, extending through the rings and threaded into the cap and the back respectively. In this case, the diaphragm is clamped in place between a ring 89 and the flanged ring 90 carried by the cap 82, the latter ring being clamped in position by means of screws 91 extending through the ring and threaded into the cap.

This invention is not limited to any specific construction disclosed, as various changes might be made in applying this invention without departing from the spirit of the invention or the scope of the appended claims.

Having thus fully described my invention, I claim and desire to protect by Letters Patent of the United States:

1. A sound box casing comprising two spaced portions, yielding substantially non-resilient means connecting said portions and means arranged to limit the outward radial expansion of said first-named means.

2. A sound box comprising an annular supporting member provided with a tubular extension rigid therewith, an annular marginal member surrounding and spaced from said supporting member, and yielding means surrounding said tubular extension and connecting said supporting member and said annular marginal member.

3. A sound box comprising an annular supporting member provided with a tubular extension, an annular marginal member surrounding said supporting member, a diaphragm carried by said marginal member, and yielding means surrounding said tubular extension and connecting said supporting member and said marginal member.

4. A sound box comprising an annular supporting member, an annular marginal member surrounding said supporting member and spaced therefrom, yielding means connecting said members and forming a closure for the space between the same, and a diaphragm carried by said marginal member.

5. A sound box comprising an annular supporting member provided with a tubular extension rigid therewith, a second annular member surrounding said first-mentioned annular member, a diaphragm carried by said second annular member, and yielding means connecting said annular members.

6. A sound box comprising an annular supporting member provided with a tubular extension rigid therewith, an annular marginal member surrounding said supporting member and spaced therefrom, and a flat yielding annulus surrounding said tubular member and connecting said members.

7. A sound box comprising a casing including an annular supporting member provided with a tubular extension rigid therewith, an annular marginal member surrounding said supporting member and spaced therefrom, a substantially flat yielding annulus snugly surrounding said tubular extension and connecting said members, and annular means overlapping and engaging the outer margin of said annulus for holding the same in position.

8. A sound box comprising a casing including an annular supporting member having a tubular extension rigid therewith, an annular marginal member surrounding said supporting member and spaced therefrom, a yielding annulus surrounding said tubular extension outside of said members, a washer surrounding said tubular extension, means for clamping said washer against said annulus, an outer washer surrounding and spaced from said first mentioned washer,

and means connected to said annular marginal member for clamping said outer washer against said annulus.

9. A sound box comprising a casing including an annular supporting member having a tubular extension rigid therewith, an annular marginal member surrounding said supporting member and spaced therefrom, a yielding annulus surrounding said tubular extension outside of said members, a washer surrounding said tubular extension, means for clamping said washer against said annulus, an outer washer surrounding and spaced from said first mentioned washer, and means connected to said annular marginal member for clamping said outer washer against said annulus, said latter washer being provided with an inwardly projecting marginal flange overlapping and engaging the marginal edge of said annulus.

10. A sound box comprising an annular supporting member provided with a tubular extension rigid therewith, an annular marginal member surrounding and spaced from said supporting member, an annular cap carried by said marginal member, a diaphragm clamped between said cap and said marginal member, and yielding means connecting said supporting member and said marginal member.

11. A sound box comprising an annular supporting member provided with a tubular extension rigid therewith, an annular marginal member surrounding and spaced from said supporting member, an annular cap carried by said marginal member, a diaphragm clamped between said cap and said marginal member, and yielding means connecting said supporting member and said marginal member, said diaphragm comprising a flat, annular yielding portion, and a comparatively rigid central portion surrounded by and secured to said flat yielding portion.

12. A sound box comprising an annular supporting member provided with a tubular extension rigid therewith, an annular marginal member surrounding and spaced from said supporting member, an annular cap carried by said marginal member, a diaphragm clamped between said cap and said marginal member, and yielding means connecting said supporting member and said marginal member, said diaphragm comprising a flat, annular yielding subereous portion, and a comparatively rigid central portion surrounded by and secured to said flat yielding portion.

13. A sound box casing comprising two separately movable portions, yielding means forming the sole connection between the said portions, and means arranged to compress said yielding m ans in one direction, said yielding means being held against expansion in a direction transverse to said first-mentioned direction.

14. A sound box casing comprising two spaced portions, yielding means holding said portions in spaced relationship, means to subject said yielding means to different degrees of compression, and means to limit the outward expansion of said yielding means.

15. A sound box casing comprising spaced portions, yielding annular means holding said portions in spaced relationship, means to subject said annular means to different degrees of compression and annular relatively rigid means inclosing said yielding means to limit the outward expansion of said yielding means.

16. A sound box casing comprising two spaced portions, yielding annular means forming a closure for the entire space between said portions, means clamping said yielding means to one of said portions, and means clamping said yielding means to the other of said portions, said portions being in contact with said yielding means upon one side only of said yielding means.

In witness whereof, I have hereunto set my hand this 19th day of January A. D., 1912.

JOHN C. ENGLISH.

Witnesses:
EDWARD K. MACEWAN,
JOHN D. MYERS.

520

DEFENDANT'S EXHIBIT NO. 11-H.

J. H. ELFERING.

SOUND BOX DIAPHRAGM.

APPLICATION FILED NOV. 12, 1910.

1,182,078.

Patented May 9, 1916.

Fig. 1

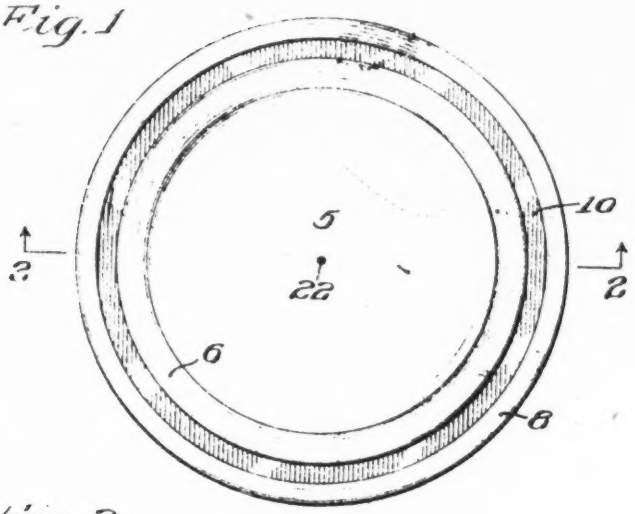

Fig. 2.

Fig. 3.

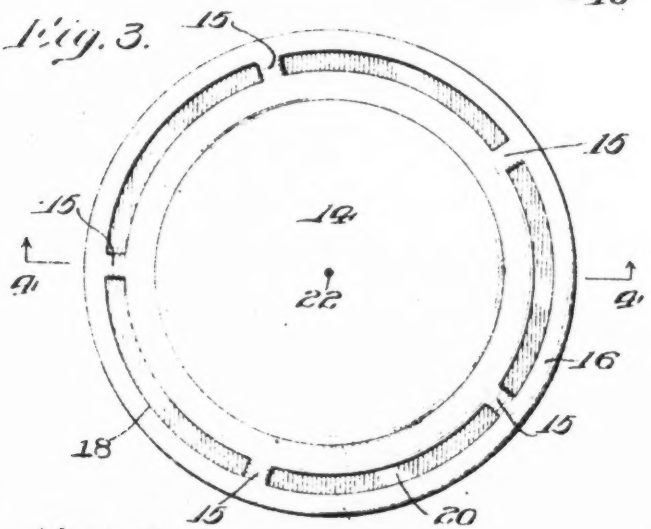

Fig. 4.

INVENTOR

John H. Elfering.

WITNESSES

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E. Ann C. Hallowell

BY

Howson & Howson

ATTORNEY

UNITED STATES PATENT OFFICE.

JOHN H. ELFERING, OF CAMDEN, NEW JERSEY, ASSIGNOR TO VICTOR TALKING MACHINE COMPANY, A CORPORATION OF NEW JERSEY.

SOUND-BOX DIAPHRAGM.

1,182,078. Specification of Letters Patent. Patented May 9, 1916.

Application filed November 12, 1910. Serial No. 591,947.

To all whom it may concern:

Be it known that I, JOHN H. ELFERING, a citizen of the United States, and a resident of Camden, in the county of Camden and State of New Jersey, have invented certain new and useful Improvements in Sound-Box Diaphragms, whereof the following is a specification, reference being had to the accompanying drawing.

This invention particularly relates to diaphragms for sound recording and reproducing devices, such as are preferably adapted to talking machines.

The principal object of this invention is to provide a diaphragm that will readily respond to the most delicate vibrations and accurately record and reproduce all of the high and low tones and the included range with equal clearness.

Further objects of this invention are to provide a diaphragm having its major portion formed substantially inflexible and capable of reciprocation independently of its margin; and to provide means to flexibly connect said inflexible major portion with said margin.

The form of this invention hereinafter described provides a diaphragm comprising a central conically dished inflexible plate, having a peripheral flange extended in a plane in substantially perpendicular relation to the axis of said conical plate, a separate annular margin surrounding said flange in a plane therewith, and a thin flexible imperforable membrane connecting said flange and margin and arranged to support said inflexible plate.

This invention further includes all of the various novel features of construction and arrangement hereinafter more definitely specified.

In the accompanying drawing Figure 1 is a front elevational view of a diaphragm showing the preferred embodiment of this invention; Fig. 2 is a central transverse sectional view taken on the line 2—2 in Fig. 1: Fig. 3 is a front elevational view of a modification of the structure shown in Fig. 1: and Fig. 4 is a transverse sectional view of the diaphragm shown in Fig. 3 and taken on the line 4—4 in said figure.

In the form of this invention shown in Figs. 1 and 2 the central major portion of the diaphragm comprises the conically dished disk or plate 5, which as best shown in Fig. 2 has the peripheral flange 6 extended in a plane in perpendicular relation to the axis of said diaphragm and surrounded by the annular marginal member 8 in spaced relation to the periphery of said flange 6, and in a plane therewith. Said marginal member 8 is connected with the flange 6 by a thin membrane 10, which may be formed by any suitable imperforable flexible material, preferably gold beater's skin, and which may be conveniently secured to said connected members by any suitable adhesive material. Said membrane 10 is arranged to support the central conical plate 5 in reciprocatory relation to the marginal member 8 which may be suitably secured in a sound box of any convenient construction.

It may be here noted that the diaphragm may be formed of any suitable material preferably paper or other fibrous material which may be treated with a resinous solution or other convenient material to render it impervious to any atmospheric conditions or moisture or may be formed of any stiff sheet material.

The form of this invention shown in Figs. 3 and 4, provides a diaphragm similar to the diaphragm shown in Figs. 1 and 2, and comprises the rigid central portion forming the conically dished plate 14 which is connected by the narrow webs or spokes 15 with a sound box engaging marginal portion 16, forming the arc-shaped apertures 18, which are local to the periphery of said diaphragm, and which permit the free relative vibration of the central portion or plate 14, with respect to the marginal portion 16 to which it is connected by the flexible membrane 20. As best shown in Figs. 1 and 3, the central plates 5 and 14 are respectively provided with apertures 22, for the convenient attachment of a stylus bar (not shown) which may be cooperative therewith to record and reproduce sound.

It is well known that in diaphragms wherein the margin is engaged in a sound box, and the intermediate portion is free to vibrate to reproduce sound, the central portion which is connected with the stylus bar is afforded the maximum vibration, while the surface intermediate of the central portion and the periphery vibrates with varying force diminishing toward the margin of the diaphragm which is engaged. Therefore it will be readily observed that a diaphragm

constructed in accordance with this invention is advantageous in that the major portion is substantially inflexible, and is reciprocated bodily, thus vibrating substantially uniformly throughout its extent, and consequently the compression and rarefaction of the air in the sound conveyer due to the vibration of said diaphragm is uniform throughout its extent.

It is not desired to limit this invention to the precise details of construction and arrangement herein set forth, as it is obvious that various modifications may be made therein without departing from the essential features of the invention as defined in the appended claims.

Having thus described my invention, I claim:

1. A diaphragm having a substantially rigid major central portion, a marginal portion connected thereto by relatively narrow flexible radial sections, and a flexible concentric membrane intermediate of said central and said marginal portions.

2. A diaphragm having a rigid major central portion connected with a marginal portion by integral relatively narrow flexible radial sections and a flexible web connecting said central portion and marginal portion together.

3. A diaphragm comprising a central comparatively rigid conical dished major portion, a surrounding portion and a plurality of radial webs and an annular web connecting said portions.

In witness whereof I have hereunto set my hand and seal this 9th day of November A. D. 1910.

JOHN H. ELFERING. [L. S.]

Witnesses:

EDWARD K. MACEWAN,

FRANK B. MIDDLETON, JR.

may be quite free, or it may be attached to the inner edge of a flat flexible ring, the outer edge of which is fixed to the casing, the said ring and member thus dividing the latter into two compartments. The flexibility of this ring, and the manner of its attachment to the aforesaid member, should not be such as to hamper or suppress the small vibratory movements of any part of the member to any appreciable extent. The said member may be made of any suitable material, and in this connection I may state that I have found aluminium to be satisfactory.

The working of the device described above will be readily understood. The vibratory movements of the portion of the armature to which the aforesaid member is attached are imparted to this member as a whole; this member therefore acts like a reciprocating piston and sets a large surface of air into vibration simultaneously and to the same or approximately the same extent at all points. In the case of the said member being conically shaped, the increased efficiency is probably due partly to the fact that the disturbances set up in the air in contact with the conical surface tend to converge and to arrive simultaneously at the region where the ear of the operator is situated. In any case the distinctness and audibility of messages received are largely increased, and the range of distance over which speech is practicable is also increased.

Dated this 22nd day of December, 1910.

HASELTINE, LAKE & Co.
7 & 8, Southampton Buildings, London, England, and
60, Wall Street, New York City, U.S.A.,
Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements relating to the Reproduction of Sound by Electrical Means.

I, SIDNEY GEORGE BROWN, of 4, Great Winchester Street, in the City and County of London, Electrical Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the reproduction of sound by electrical means and has particular reference to telephone receivers.

The usual telephone receiver consists of a polarised electro-magnet through the coil of which the line currents pass, and a flat soft iron diaphragm gripped peripherally and thereby held a short distance away from the electromagnet. Variations in the strength of the line current cause the diaphragm to vibrate, and, in so doing, to set the surrounding air into vibration.

In order to obviate the unequal extent of vibration of different points on a peripherally gripped diaphragm proposals have been made to support the diaphragm at its centre leaving the periphery free, or to provide for resiliency or flexibility between the diaphragm proper and its peripheral support, thereby obtaining a piston-like action of the diaphragm. It has been suggested to form such diaphragms of metal, ebonite, or other suitable material, and to impart to them a conical or dished appearance. The chief object of the present invention is to provide an instrument of this kind in which a high efficiency of conversion of oscillations or variations of electric current into acoustic vibrations is obtained. Apart from the actual construction and positioning of the parts of such an instrument, the conditions necessary for the transmission of the air vibrations away from the actual surface of the diaphragm

importance. Hitherto sufficient attention has not been paid to the volume of air set in motion and the variations of air pressure for producing the most effective transmission. The dimensions of the ear-drum and of the aural cavity may be taken as invariable factors in such considerations. Now these factors being known, there are certain relations existing between them and the size of the diaphragm, the nature of the air pressure variations, and the volume of air set in motion, for the most effective reproduction of the sounds, and the transmission of them to the ear-drum. For these and other reasons it is quite impracticable to make the diaphragm fulfil also the functions of an ear piece; a separate ear piece is a necessity.

According to the present invention the receiver comprises a light conical or similarly shaped diaphragm, a resilient member responsive to variations of current strength in a coil through which the line currents pass and carrying the diaphragm by its centre so that the latter is free to vibrate as a whole, and a cover or ear piece situated over the diaphragm at a comparatively short distance from the same. The inner surface of the cover or ear piece of the receiver is preferably formed to correspond approximately with the shape of the diaphragm, so as to reduce the excessively large space that would otherwise intervene between these parts. I have found that a conical disc formed from a very thin sheet of aluminium or aluminium alloy or steel and suitably stiffened by ribs, or corrugations, or otherwise, possesses the requisite properties to a satisfactory degree. The thin disc, if of aluminium or an alloy thereof, may conveniently be spun into the desired conical shape with a flat centre piece. It is advantageous for the strength and thickness to be greatest at the centre and progressively less towards the edge, and by starting the spinning operation at the edge and working towards the centre, this property of the spun disc will be naturally produced owing to the graduated thickness of the disc. To increase this effect several discs of different diameter may be assembled into a pile. The thickness of such discs may be of the order of 2½ thousandths of an inch. Some idea as to the lightness of a diaphragm so formed may be gained from the fact that when it is allowed to drop to the ground it does not fall like a heavy mass of metal, but moves gently through the air. The mere conical shape of the diaphragm will ensure a considerable amount of rigidity but this may be increased by providing radial ribs or corrugations on it as above mentioned.

The vibratory member that carries the diaphragm may consist of a resilient strip or reed of magnetic metal containing within itself, by reason of a cut-away portion, its own control and that of the diaphragm. The diaphragm is preferably attached at its centre to a point on the metal strip or reed slightly away from the free end of the latter so as to be eccentric with respect to the axis of the coil through which the line currents pass. The diaphragm is so arranged as to be free to move as a whole, that is to say all points on its surface vibrate equally, and to ensure this action the periphery of the diaphragm is either quite free or is attached to the usual casing by a mere thin ring of flexible material.

In order that the invention may be clearly understood and readily carried into effect I will now describe the same more fully with reference to the accompanying drawings, in which:—

Figure 1 is a plan with the cover removed, and

Figure 2 a sectional elevation, of one constructional form of my improved receiver. These drawings represent a full size receiver, and the more important dimensions such as the diameter of the diaphragm, the extent of its eccentricity, and the volume and shape of the air space between the diaphragm and the ear-piece or cover are what I have found by experiment to give good results for hearing with the receiver close to the ear, by reason, no doubt, of the relation these dimensions bear to the diameter of the ear-drum and the volume of the aural cavity. Where it is desired to make the sounds travel out into the room, a receiver of larger size is preferable.

Figures 3 and 4 are detail sectional elevations of modifications of the receiver.

Referring first to Figures 1 and 2, A is the casing and B the ear-piece or cover of the receiver. E is a metal reed one end of which is held down upon a bridge piece E^1 on the casing E by two adjusting screws E^2. N and S represents the north and south poles, respectively, of a polarised electromagnet to the ends of which are attached L-shaped pieces the vertical members of which, constituting the cores D, have the coil C wound around them; the ends of the said vertical members slope towards one another so as to be directly under the metal reed E. A portion E^3 of the reed E is cut away to increase its flexibility and decrease its weight. I have found that a suitable free period for the reed is from eight hundred to one thousand two hundred. The extent to which the reed E can approach the core D may be regulated by packing some layers of paper between these parts or by arranging a set screw to make contact with the reed, the provision of a set screw being shewn at D^1 Figure 3. This set screw D^1 may be tipped with gold or platinum so as to serve in conjunction with the reed E as a make and break arrangement in a circuit connected in parallel with the coil C. In this way any damage to the permanent magnetism of the core D owing to an extra heavy current passing through the coil C at any time is avoided, since the closing of the shunt circuit by the contact of the reed E with the set screw D^1 diverts the current away from the coil C.

F is a light aluminium diaphragm of conical form. It is attached at its centre to the reed E at a point eccentric with respect to the axis of the core D, the eccentricity being towards the fixed end of the reed. Although I have shown the best position for attaching the diaphragm in the particular receiver illustrated, the best position on any reed can be found by experiment by means of a stethoscope and by exploring the reed with the aid of a movable diaphragm.

The diaphragm F is either of such a size that its periphery is close up against the casing A or other adjacent stationary part, or, if an appreciable gap exists between these parts, the periphery of the diaphragm is flexibly attached to the casing or to a removable internal flange thereon by resorting to the known expedient of a ring of tissue paper, silk, or other suitable material F^1 that will not exert any appreciable mechanical constraint upon the diaphragm; this ring F^1 may be attached to the diaphragm and to the aforesaid flange by adhesive. In either case the space on the two sides of the diaphragm is divided into two separate air regions.

In the modification, shown in Figure 4, the north pole of the polarised electromagnet is surrounded by a ring-shaped south pole. In the annular space between these poles is situated a circular frame C^1 on which is wound the coil C. The frame C^1 is carried by the metal reed E. Variations in the strength of the current traversing the coil C cause this coil C to move vertically and thereby cause the frame C^1 to vibrate the reed E, and consequently the diaphragm F also. In this construction it is to be noted that the movements of the reed E do not materially affect the magnetic field between the poles of the electromagnet.

It will be understood that owing to the extreme lightness of the diaphragm and to its freedom from peripheral constraint, it will be highly responsive to movements of the reed E and will vibrate as a whole.

It will also be observed that the function of the reed E is not to set the air in motion but only to carry the diaphragm and control its movement. This reed contains within itself, by reason of its cut away portion E^1, the means of its own control and that of the diaphragm, and, in the arrangement shown in Figures 1 and 2, also serves to complete the magnetic circuit; the diaphragm forms no part of this circuit. The inner face of the cover or ear-piece B conforms approximately to the shape of the diaphragm, and its distance from the diaphragm is such as to give only the requisite air space between these two parts. The sectional area of the central hole or holes in the ear-piece is suitably proportioned to the aforesaid air space.

Improvements relating to the Reproduction of Sound by Electrical Means.

Although the invention has been described and illustrated with reference to a "watch" type of receiver, it is of course equally applicable to the long handle type of receiver. It has been proved by actual experiment that receivers possessing the constructive features hereinbefore described considerably increase the maximum distance over which distinct speech can be conveyed.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A telephone receiver comprising a light conical or similarly shaped diaphragm, a resilient member responsive to variations of current strength in a coil through which the line currents pass and carrying the diaphragm by its centre, and a cover or ear piece situated over the diaphragm, substantially as and for the purposes specified.

2. A telephone receiver in which the inner surface of the cover or ear piece situated over the conical or similarly shaped diaphragm corresponds approximately with the shape of the diaphragm, substantially as and for the purpose specified.

3. A telephone receiver comprising a casing, a resilient member responsive to variations in the strength of the line current, a light conical or similarly shaped diaphragm carried at its centre by the resilient member, and a ring of thin flexible material connecting the periphery of the diaphragm with the adjacent wall of the casing or other stationary part, substantially as and for the purpose specified.

4. A telephone receiver, in which the diaphragm attached to the resilient member that is responsive to variations in the line current is situated eccentrically with respect to the electro-magnet, the eccentricity being towards the fixed end of the resilient member, substantially as described.

5. In a telephone receiver, a conical diaphragm built up, or radially corrugated or ribbed, or spun from a disc, in such a way as to be strongest at the centre and of diminishing strength towards the periphery, substantially as described.

6. A telephone receiver, comprising a polarised electro-magnet through the coil of which the line currents pass, a magnetic armature having a cut-away portion to impart resiliency to it, a conical aluminium diaphragm attached to the armature eccentrically with respect to the electromagnet and towards the fixed end of the armature, and a thin flexible ring of material connecting the periphery of the diaphragm to an internal removable flange on the casing, the latter having a conical inner face conforming approximately to the shape of the diaphragm, substantially as described.

7. A telephone receiver having its parts constructed arranged, and adapted to operate, substantially as hereinbefore described with reference to the accompanying drawings and for the purposes specified.

Dated this 19th day of June, 1911.

HASELTINE, LAKE & Co.,
7 & 8, Southampton Buildings, London, England, and
60, Wall Street, New York City, U.S.A.,
Agents for the Applicant.

A.D. 1910. Dec. 22. No. 29,833
BROWN'S Complete Specification
(1 SHEET)

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Fig. 1.

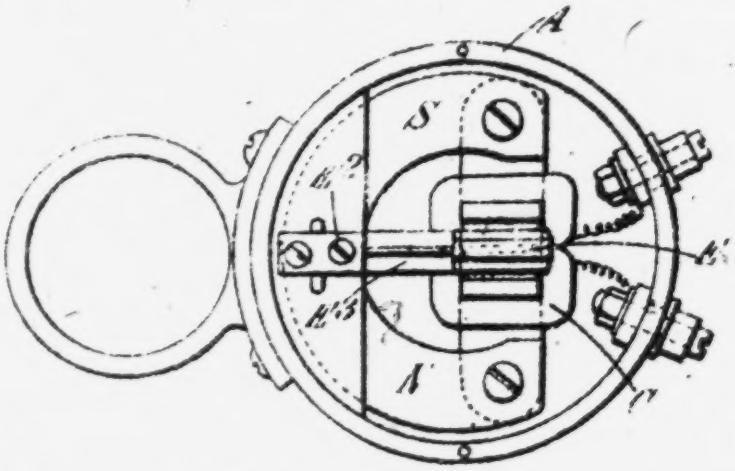


Fig. 2.

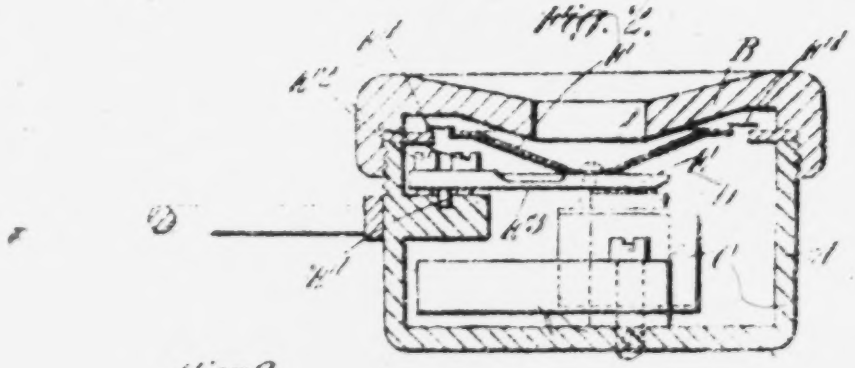


Fig. 3.

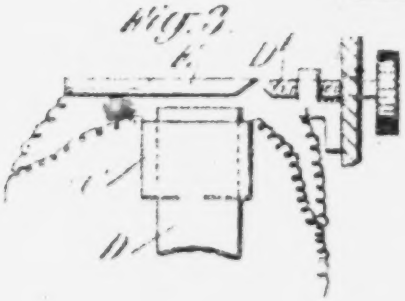
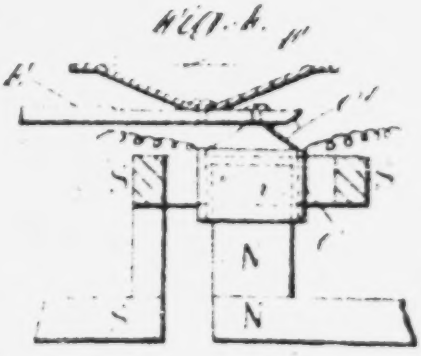


Fig. 4.


A'
A''
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be such that no great changes in the pressure conditions of the air are made to occur suddenly as the air vibrations travel outwards from the actual surface of the diaphragm. In other words an air space that ensures a gradual and uniform change in the pressure conditions of the air should extend not only from the broad outer end of the trumpet to the narrow end of the same or of the tone arm, but should also enable the best air conditions to be maintained between the said narrow end and the actual surface of the diaphragm. The narrow end of the trumpet or of the tone arm may be formed with a single passage leading up to the centre of the diaphragm, or it may comprise several passages the total sectional area of which is not greater than that of the single passage at the point where it branches.

In view of the comparatively large area of the diaphragm above described, the sectional area of the narrow end of the trumpet or tone arm may be proportionally large, in which case a trumpet with a straight passage would suffice to affect the necessary gradual reduction in the air pressure of the acoustic vibrations before they reach the free air. In the case, however, of a trumpet or tone arm with a narrow end of small sectional area, the passage provided might require to be objectionably long if it were kept straight whilst preserving a gradual and uniformly decreasing sectional area along it, and it may in such cases be advantageous to make the passage tortuous, one portion of it being situated within the other portion or portions.

Dated this 16th day of January, 1911.

HASELTINE, LAKE & Co.,
7 & 8, Southampton Buildings, London, England, and
60, Wall Street, New York City, U.S.A.,
Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements relating to Gramophones and the like.

I, SIDNEY GEORGE BROWN, of 4, Great Winchester Street, in the City and County of London, Electrical Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to gramophones and the like the chief object being to so construct and mount the diaphragm of the usual sound box that it is extremely sensitive or responsive to vibratory influences.

In the ordinary sound box arrangements of gramophones and the like, one end of the stylus bar or lever is attached to the centre of the diaphragm and the latter is gripped peripherally, with the result that since it is not absolutely free to vibrate freely at all points on its surface its responsiveness to vibratory influences is far from being efficient; moreover it is usually comparatively heavy with the result that its inertia makes it sluggish in action.

With a view to removing some of the constraint put upon the diaphragm by reason of its peripheral mounting, it has been proposed to form it with a conical centre portion and a resilient flange portion so that the conical centre portion, the apex of which is secured to the stylus bar or lever, may vibrate as a whole; in such a construction, however, the damping and constraining action of the flange portion is in my opinion too great to ensure acoustical efficiency. It has also been proposed to transmit the vibrations of the stylus bar to the conical diaphragm through a connecting rod and to mount the diaphragm peripherally by a flexible mounting of a folding character such as

gold-beater's skin so as to ensure a movement of the diaphragm as a whole. I have found by experiment that maximum acoustical efficiency cannot be realised by merely causing the diaphragm to exercise a pumping action upon the air and that in particular a peripheral mounting should be avoided.

The solution of the problem seems to lie in causing the diaphragm to vibrate in such a way that its centre is a node and its periphery an anti-node. The vibrations that the diaphragm should in my opinion perform may be likened to those of a bell the thickness of which is reduced to such an extent that its vibrations are as large as possible in amplitude consistent with being just capable of being damped by the setting up of waves in the adjacent air. Since the centre of the diaphragm requires to be a node the diaphragm should be rigidly mounted by its centre on the stylus bar, and since the periphery requires to be an anti-node it must either be entirely free, or be connected to the casing or other stationary part by material so light and thin that no appreciable peripheral constraint is exercised. The peripheral connection between the diaphragm and the casing or other adjacent part must not be a good absorber of energy, since if it were it would damp the periphery of the diaphragm; on the other hand although it should possess resiliency it must not offer any appreciable mechanical constraint to the periphery. Consequently it must be composed of extremely thin and light resilient material.

According to the present invention, therefore, I realise the above conditions by rigidly mounting a conical or equivalently shaped diaphragm of very light weight by its centre on the usual stylus bar or lever, leaving its periphery either entirely free but very near to the casing or other stationary part, or connected to the latter by a ring of resilient material of extreme thinness,—considerably thinner than the diaphragm periphery itself,—the formation and the mounting of the diaphragm being in either case such that its centre is in a nodal and its periphery in an anti-nodal condition. The ring of material, if used, may be connected by adhesive and should have a small amount of sag in order that the diaphragm periphery may vibrate without having any appreciable drag exerted upon it by the ring. Since the diaphragm must be very light though rigid, it may conveniently be formed from aluminium or aluminium alloy, being spun from a thin disc of the same into a conical shape with a flat centre piece. The thickness should be of the order of thousandths of an inch a satisfactory average thickness being 2½ thousandths. It is advantageous for the strength to be greatest at the centre and progressively less towards the edge, and by starting the spinning operation at the edge and working towards the centre, this property of the spun disc will be naturally produced. To increase this effect, several coned discs of different diameter may be assembled together so as to form a pile. In the case of a diaphragm thus built up, the several coned discs may differ in the sharpness of their conical angles.

Owing to the shape and lightness of the diaphragm and to its being rigidly mounted by its flat centre piece it responds very sensitively to sound waves striking upon it and efficiently absorbs the energy of these waves into its substance and concentrates this energy at the centre, and since this is the part at which the support is applied the energy is transmitted with maximum efficiency to the supporting means, that is to say to the stylus bar or lever.

Conversely, in order that the diaphragm may operate to reproduce sound efficiently, it must be extremely light and thin in order that the vibrations imparted to its nodal region may travel through its substance and develop into movements of large amplitude at its anti-nodal periphery: it will be understood that if the amplitude of the vibrations travelling in the substance of the diaphragm is low, and if reflected waves are produced in its substance, as would be the case with a comparatively heavy thick diaphragm, the energy of the vibrations would not be given off to the surrounding air efficiently. It is also essential that the only support for the diaphragm should be that through which the vibrations are imparted to it. Again, it is essential for the support

to be applied at a part from which the energy of vibrations transmitted by means of the support to the diaphragm can spread out uniformly through the substance of the diaphragm. Moreover, the diaphragm, although light and thin, must be rigid, since otherwise the energy absorbed by the diaphragm becomes wasted in useless unsymmetrical and uncontrollable motions. A diaphragm constructed and mounted as above described complies with these requirements.

If the conical shape does not impart to the diaphragm all the requisite rigidity, it may also be ribbed or corrugated radially in the known manner. Some idea of the lightness of a diaphragm so formed may be gained from the fact that when it is allowed to drop to the ground, it does not fall like a mass of metal, but flutters like a leaf or piece of paper.

In order that the said invention may be clearly understood and readily carried into effect, I will describe the same more fully with reference to the accompanying drawings, in which;—

Figure 1 is a vertical section, and

Figure 2 a rear elevation of a sound box, diaphragm, and stylus lever, constructed in accordance with the invention.

A is the rear part and B the front part of the sound box, C is the diaphragm, and D the stylus lever. The cross piece D^1 carrying the stylus lever D is held against the two knife edges A^1 on the rear part A by two screws D^2 beneath the heads of which are spring washers D^3. The diaphragm C is attached to the stylus lever D at its flat centre piece, and the periphery of the diaphragm is shown connected to the sound box by the ring C^1 of extremely thin resilient material such as glazed tissue paper one three-thousandths of an inch thick or thin collodion film. The width of the annular space must either be so small that the two air regions on the two sides of the diaphragm may be considered as without communication with one another or the ring of material must be used; in the latter case the ring should be slack enough to permit of the diaphragm's movements without any appreciable mechanical constraint being put upon it. This ring instead of being connected directly to an integral part of the sound box, as shown, is preferably connected to a removable metal ring clamped between the rear and front parts. If more constraint upon the bodily movements of the diaphragm is required than is given by the stylus lever, the diaphragm and stylus lever might be secured to a blade spring fastened diametrically across the open central space of the rear part A. However, in most cases such a constraint is not necessary.

The rear part A of the sound box may be formed with several holes A^2 so that the air behind the diaphragm may not be imprisoned to such an extent as to interfere with the vibratory movements of the diaphragm.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim in connection with gramophones and the like is:

1. A very light and conical or equivalently shaped diaphragm rigidly mounted by its centre on the usual stylus bar or lever, leaving its periphery either entirely free but very near to the casing wall or other stationary part, or attached to the latter by a ring of resilient material of extreme thinness,—considerably thinner than the diaphragm periphery itself,—the formation and the mounting of the diaphragm being in either case such that its centre is in a nodal and its periphery in an anti-nodal condition, substantially as and for the purposes specified.

2. A conical diaphragm so formed or constructed as to be thickest at the centre and of decreasing thickness towards the periphery, substantially as and for the purposes specified.

3. A diaphragm formed by spinning a thin disc of aluminium or aluminium

alloy into a conical shape, the spinning being commenced at the periphery of the disc and continued towards the centre, substantially as and for the purposes specified.

4. A diaphragm built up of several cones of different diameters, substantially as and for the purpose specified.

5. Apparatus having its parts constructed, arranged, and adapted to operate, substantially as hereinbefore described with reference to the accompanying drawings for the purposes specified.

Dated this 17th day of July, 1911.

HASELTINE, LAKE & Co.,
7 & 8, Southampton Buildings, London, England, and
60, Wall Street, New York City, U.S.A.,
Agents for the Applicant.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 2.

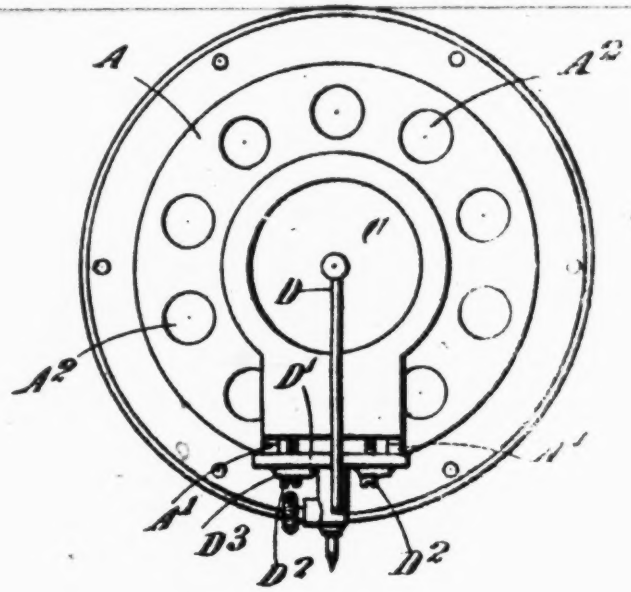
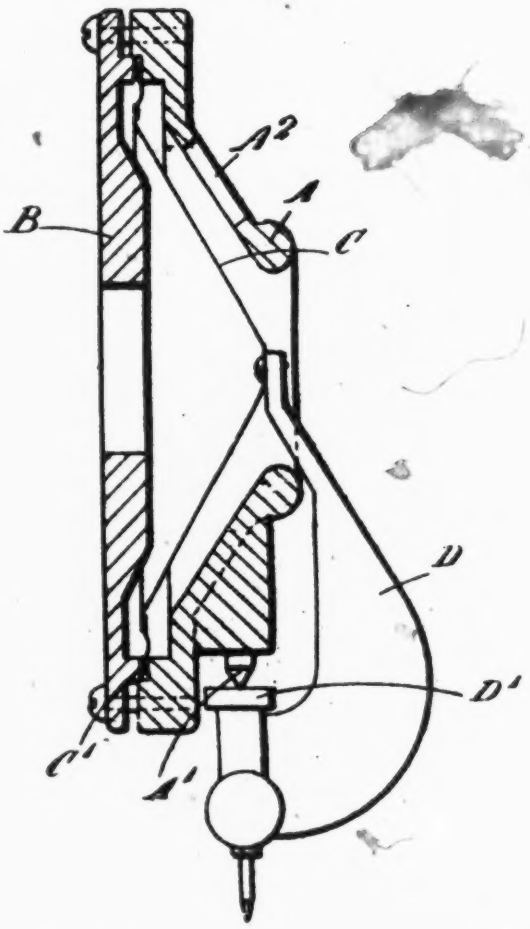


Fig. 1.



Also I may use differentially-wound or other transformers for the purpose of communicating electrically between each microphone and the receiving or vibrating coil of the next in the series. The vibrating coils may be wound of fine wire compacted together with cement such as shellac, or they may be of metallic ribbon when extra low resistance is desired.

Furthermore for the purpose of a "call," a tone-telephone such as a tuning fork or other persistent vibrator mounted on a sound board may be employed as the last of the series of telephone relays, so as to respond powerfully when alternating currents of its own frequency are excited at the distant station.

For the purpose of discriminating between a number of call stations a combination of differently attuned forks or tone-telephones may be arranged instead of one, so that each shall respond strongly only to its own note and thus indicate the particular station which is desiring to signal. The receiving or collecting circuit may likewise in some cases be attuned to a definite note. At the sending end a battery connected to an acoustic arrangement, such as a reed, or a string or other rapid intermitter or reverser of current, may be used to stimulate a circuit containing both capacity and self induction, so that it shall be thrown into strong electromagnetic vibration.

Dated this 27th day of April 1898.

A. F. SPOONER,
323, High Holborn, London, Agent for the Applicant.

COMPLETE SPECIFICATION.

Improvements relating to Telephones, and to Circuit Arrangements and Relays therefor.

I, OLIVER JOSEPH LODGE, F.R.S., D.Sc., of 2, Grove Park, Liverpool, in the County of Lancaster, Professor of Physics in University College, Liverpool, aforesaid, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The chief objects of my invention are to provide means for the audible detection of extremely feeble fluctuating electric currents, such for instance as may be caused in a closed, or practically closed, circuit, by another very distant circuit supplied with alternating currents; to magnify the telephonic effect of feeble currents by successive specially-designed relays until the sound is sufficient to act as a "call" summoning the operator to attend to receive the message; to magnify the telephonic effect of speech so that conversation transmitted round one circuit may be heard inductively in a different circuit provided with proper instruments; and generally to improve the conditions under which telephony is carried on so as to magnify every fluctuation of current and thus produce a loud sound from a feeble stimulus for any useful purpose.

For the purpose of detecting or manifesting any feeble alternating or intermittent current, whether excited microphonically or inductively or otherwise, I construct a special kind of telephone or relay, the main features of which are depicted in the annexed drawings. It consists of a coil of insulated wire or metal ribbon a supported freely by an elastic spring b (Figure 3) or by one prong of a tuning fork b^1 (Figure 2) in a strong magnetic field produced by an electromagnet or permanent magnet c of which one pole c^1 is inside the coil while the other pole or keeper c^{11} is outside and surrounding it. The coil is constructed of light materials well cemented or fixed together so as to move as a rigid body, and whenever an alternating current passes round it, it is thrown into bodily vibration, and

transmits these vibrations mechanically to whatever is connected to it. The said coil may be attached in any light and rigid manner to a sound board *d* (Figure 1) or to the diaphragm d^1 (Figure 7) of a microphonic transmitter, or it may carry a piece of graphite, carbon, or other suitable substance d^{11} (Figures 2 and 3) so that the sound board, the diaphragm, or the carbon, receive the mechanical vibrations.

The object of transmitting the vibrations to the sound board *d* is to make them directly audible. The object of transmitting them to the microphonic carbon granules or pellet is to actuate a kind of microphonic relay which by throwing into intermittent action the current from a local battery shall greatly magnify the intensity of the originally received disturbance.

The sound-board receiver is depicted in Figure 1, where *e* is a thin aluminium or other light cone or tripod connecting the vibrating coil *a* rigidly to the sound board *d*, which may be of large size and may have a number of similar coils attached to it in various parts. For instance it might form the ceiling or wall of a public hall: and the alternating current originally received by the several coils would in that case be caused by the voice of a speaker directed towards any form of microphonic transmitter capable of distinct articulation.

In the case of Figure 1 the sound board *d*, or in the case of Figure 7 the diaphragm d^1, itself constitutes the elastic support of the coil *a* and dispenses with the necessity of the separate spring such as that shown at *b* in Figure 3. Only one end of the keeper c^{11} is shown in Figures 1 and 2; the side of it is indicated in Figure 3, and it continues to the other pole of the magnet which it similarly surrounds as shown in Figures 5^x and 5^y. In all these figures, the keeper is supported rigidly from the pole by means of a brass collar and plate *f*.

A form of magnet is shown in Figure 4 (which represents a plan and elevation respectively) where the keeper c^{11} is a round plate of soft iron pierced with holes for the reception of four poles like c^1 and where c_0 is a bundle of hard steel magnets, joined to the four rods c^1 by an iron base plate c_3. Or else, as an alternative arrangement, the whole is of soft iron and the space *g* surrounding the central shaft is filled with wire, constituting it an electromagnet. Thus a magnet with four pole pieces like c^1 and four annular air gaps or inter pole spaces a^x to receive four vibrating coils such as *a* shown in the other figures is produced.

Figures 5 and 5^x illustrate in plan: Figure 5^y in side elevation: and Figure 5^z in vertical section, an alternative form of steel magnet and its keeper. The magnet is one of ordinary horseshoe shape with two poles *c* and soft iron pole pieces c^1 surrounded by a soft iron keeper c^{11} attached rigidly by the brass collar-plate *f* to the pole pieces.

The coil *a* instead of being attached to a metal diaphragm held near the ear, or to a sound board as described, may in the first instance be mechanically attached to the diaphragm of a granular microphone as shown in Figure 7 or to some other microphonic arrangement fed by a local battery and having in its circuit (through a transformer or otherwise) another telephone as shown in Figure 6, which may be either of any usual pattern or of the above described new pattern with vibrating coil. This second movable or trembling coil may thus actuate by mechanical means another microphone which, through the energy of its relay battery, may powerfully disturb a third telephone, and this again if necessary a fourth and so on. The whole arrangement is depicted in Figure 6 where the concluding telephone of the series is indicated in two alternative forms either of which may be switched on by the switch *m*. By this means any required degree of magnification can be obtained, for I find that a coil thus moving as a whole in a magnetic field (otherwise maintained) is very suitable for communicating its tremors to a microphone-transmitter whether of special or of any customary form: being much more effective for this purpose than the ordinary iron diaphragm receiver which vibrates in parts and is under considerable constraint. The final instrument of the series is usually a loud speaking iron disc or diaphragm telephone of some ordinary pattern suitable for imparting vibrations to the air and so on to the ear; or it may

be an electro-dynamometer or a Langdon-Davies phonophoric receiver, or other instrument, for example, that shown in Figure 8, whereby the vibrations are enabled through a relay to work Morse or other telegraph instruments.

I may use this plan of magnification as a call, or as a receiver in magnetic telegraphy, but it is obviously applicable to other useful purposes such as magnifying a speaker's voice by distributing it to various parts of a large hall.

The main features of the microphonic relay or magnifying telephone are shewn in detail in Figures 2 and 3, where the vibrating carbon d^{11} is in light contact (it is shown separated in the figures for clearness) with another piece of carbon or other electric conductor h which is firmly held and adjusted by a thumb screw i working in a suitable support j. It is to be understood that the support j and the spring b or the prong of the tuning fork b^1 are to be connected to a local battery circuit which shall also be connected either directly or through a transformer with the coil of another second receiving telephone. This second telephone thus supplied with intermittent or alternating currents of magnified intensity may be a telephone of ordinary pattern, or it may be a vibratory coil telephone like Figure 1, or it may be another relay telephone like Figures 2 and 3 or like Figure 7 which then in turn magnifies further and operates another telephone, and so on.

Figure 6 serves to show the connexions for such a series of magnifying telephones, or telephone relays. In that figure the coil and condenser indicated at A B represents subject matter described in the Specification of another Application for Letters Patent filed by me and numbered 29,505 dated 13 December 1897, though it may be replaced by any other transmitting or collecting apparatus: for instance this original current fluctuator might be an ordinary microphonic transmitter operated by the voice. The Roman numerals I, II, III and IV represent a possible arrangement of the receiving and magnifying apparatus. No. I is a relay telephone like Figure 2 or Figure 3 with a vibratory coil varying the microphonic contact of the carbons d^{11} and h, one of them being supported by the spring b. No. II is another relay telephone like Figure 7 adapted to stronger currents, with its vibratory coil varying the microphonic contacts in a granular transmitter with its thin carbon diaphragm d^1 and carbon base h^1. No. III is a loud-speaking telephone consisting of a vibratory coil and sound board, like Figure 1. No. IV represents another form of loud-speaking telephone, alternative to the last, where a vibratory diaphragm disturbs the outer air through a concentrating funnel. The magnet in Nos. I II and III is supposed to be an electromagnet shaped like Figure 4, but with only a single air gap surrounding the central shaft C_6 which is wound with a magnetizing helix and surrounded by an outer iron cylinder instead of the four rods c^1 of that figure. The magnet of No. IV is supposed to be more like the horseshoe pattern of Figures 5 to 5°: or it may be any known form of loud-speaking telephone. Electrical connection between I and II and between II and III is effected by means of the transformers k_1 and k_2: l_1 and l_2 are the local batteries, of which l_2 is permissibly stronger than l_1, because of the many contacts in the granular microphone d^1 h^1. Instead however of the speaking telephone No. III a modification called a "call telephone" may be employed. The design of this is depicted in Figure 8 where the coil, suspended as before in a field due to the magnet c by the rigid light connector e, operates the limb of a spring or of a tuning fork b^1 clamped to the pillar n and carrying an adjustable counterpoise o for the purpose of equalizing the load on both prongs, and also permitting a slight range of tuning. The studs p and q are platinum, lightly in contact, the upper one q being held by the thin spring r and adjusted by the thumb screw i. The pillar j supporting this spring is insulated, as for instance by the ebonite s, and thus n and j can be connected to a local battery circuit containing an ordinary relay the tongue of which is just held over by the current across the junction p, q so long as that junction is undisturbed. But directly the fork trembles, the contact between p and q is practically broken or greatly enfeebled, by the dancing of the light spring r on the heavier spring b^1, and accordingly the tongue of the

relay in circuit with p, q (that is with n, j) moves over and completes the circuit of an ordinary electric bell or it may work a Morse instrument.

For the purpose of discriminating between a number of "call" stations a combination of differently attuned forks or tone telephones may be arranged, instead of one, so that each shall respond strongly only to its own note and thus indicate the particular station which is desiring to signal. The receiving or collecting circuit may likewise be attuned to a definite note, as detailed in the specification of my said prior application.

Whether the spring b or the tuning fork b^1 is employed as the elastic support for the coil in any case is optional, but whenever precision of tuning is desired, so that the receiver shall respond to one particular frequency of distant impulses and not to others, I prefer the tuning fork: and in that case it would be preferable to make Nos. I, II and III of Figure 6 all tuning-fork telephones. But where many notes, or where speech is desired to be received and magnified, then either a spring or a diaphragm or some other elastic support can be used. Further I find that a microphone acts best when a certain strength of current is passing through it: so whenever the receiving telephone is of too high resistance to permit this strength of current to flow in simple circuit with it I shunt the telephone by means of a low resistance self-induction or choking coil which conducts the main part of the steady current but diverts the variations of current through the telephone. On a long line a transformer is the natural mode of achieving this object but on a short or purely local line I find the choke shunt preferable.

To enable a fairly strong current to be sent through a microphonic transmitter without over-disturbing a telephonic receiver, I shunt the latter out by a self-induction or choke coil t, as indicated in Figure 9, where the transmitter b^1 is shown operated by one of the vibrating coils a as in Figure 7 but its telephonic receiver is shunted by the coil t, whereby the steady current is mostly conveyed, while its rapid fluctuations mostly go through the telephone. To assist the fluctuation to go through the telephone, I place a condenser u in series with it as shown in Figure 10. This has the effect of strengthening oscillations of some particular frequency in especial, and of all frequencies not too far removed from that.

It is to be understood that the microphone transmitter may be worked by the voice or by any other usual arrangement, and is not limited to the disturbance by attached coils.

Whenever a temporarily inoperative microphone is in circuit with a telephone (as for instance the ordinary transmitter belonging to a local receiver during the reception of a distant message), an accidental noise, a grating or hissing, is usually going on in the telephone. This can be diminished by shunting the telephone with a condenser v, as indicated in Figure 11, an arrangement which is advantageous in some forms of ordinary voice telephones, as it diminishes the disturbing noise from the local transmitter while the desired message from a distant transmitter is being listened to.

This and the other methods mentioned, though specially applicable to such pure-tone-telephony as is appropriate for Morse signals, can also be used with speech-telephony under certain conditions.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A telephone having a coil freely supported in a magnetic field upon an elastic spring or its equivalent substantially as and for the purposes set forth.

2. In a telephone, the combination of a coil freely supported upon an elastic spring or its equivalent with a magnet one pole of which is inside the coil while the other pole is outside and surrounding it substantially as and for the purposes set forth.

3. The method, substantially as set forth, of attaining forcible mechanical or acoustic vibrations from fluctuating electric currents by a telephone consisting

of an elastically suspended movable coil, suspended in an annular or other suitable magnetic field, and connected with a sound board, or its equivalent.

4. The method, substantially as set forth, of magnifying feeble mechanical vibrations electrically received by means of a vibrating coil so arranged as to operate a microphone or microphonic transmitter whose current serves to work another telephone.

5. The combination of a series of telephones and microphones connected alternately electrically and mechanically, so that each telephone receives a disturbance electrically from the preceding microphone and passes it on mechanically in magnified intensity to the next microphone, while each microphone receives a disturbance mechanically from the preceding telephone (or in the case of the first of the series possibly from the voice direct) and passes it on electrically to the next telephone of the series.

6. The microphonic relay or magnifying telephone constructed substantially as described with reference to Figures 2 and 3 of the accompanying drawings.

7. A magnet with one or more inter pole spaces each containing a suspended coil of wire arranged to receive fluctuating currents and thereby to be thrown into vibration substantially as described with reference to Figure 4, or to Figures 5, 5^A, 5^B, and 5^C of the accompanying drawings.

8. As a telephonic "call," a light metallic contact in a local relay circuit arranged so that it dances on an elastic vibrator and thereby changes in electrical resistance when the vibrator is excited by means of fluctuating currents sent round an attached coil suspended in a magnetic field substantially as described with reference to Figure 8 of the accompanying drawings.

9. In a telephonic arrangement, the combination of a magnet, a mechanically vibrating coil surrounding one of its poles, a microphone, and a telephone or its equivalent substantially as and for the purposes set forth.

10. In combination, a tuning-fork or reed and a vibrating coil substantially as and for the purposes set forth.

11. In combination, a tuning fork or reed, a vibrating coil and a loose contact attached to the tuning fork for the purpose of operating a relay and so furnishing a "call" substantially as set forth.

12. In a telephonic circuit the choke coil t substantially as and for the purpose set forth.

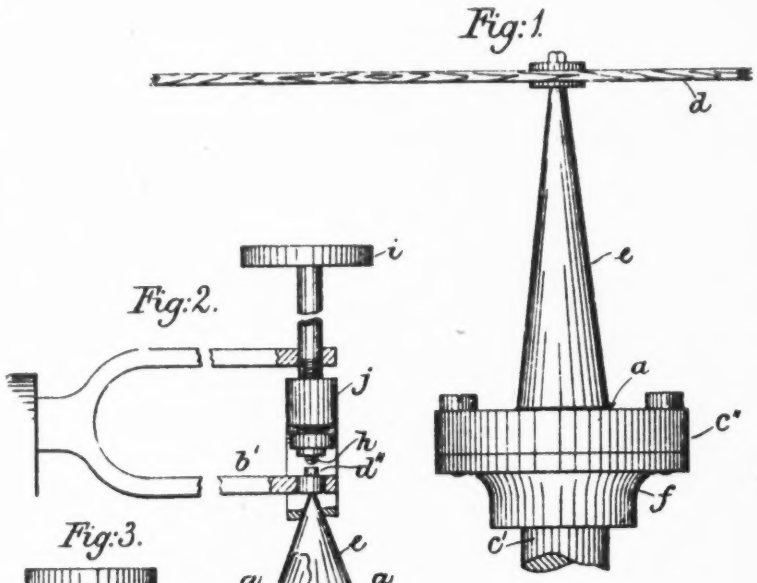
13. In a telephonic circuit the condenser v substantially as and for the purpose set forth.

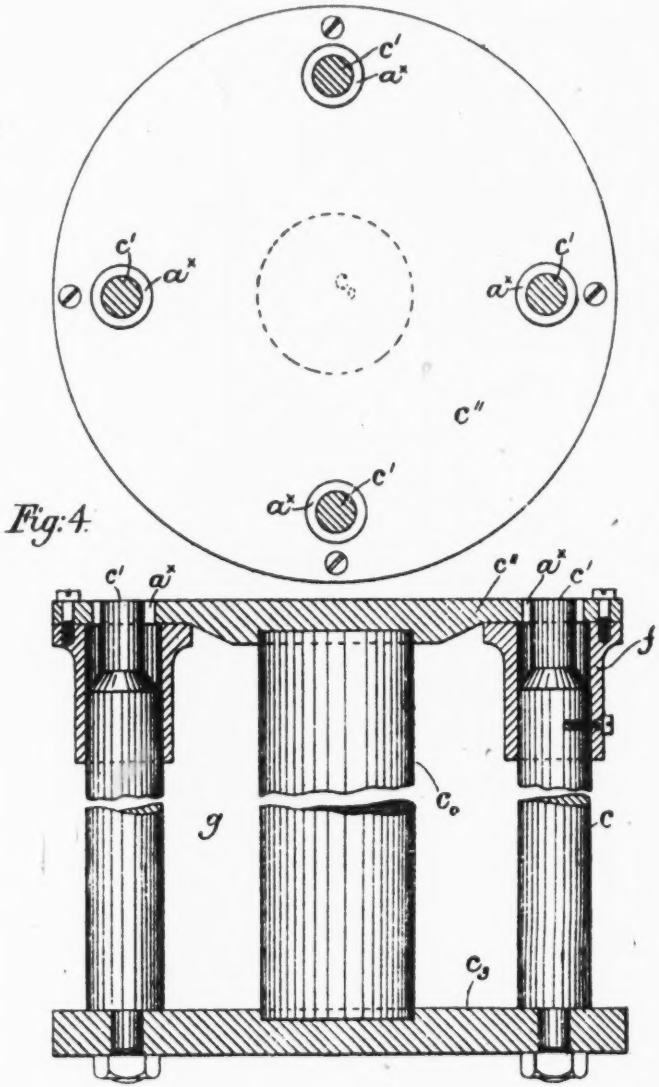
14. The combination, in a telephonic circuit, of the choke coil t and the condenser u substantially as and for the purpose set forth.

Dated this 13th day of December 1898.

A. F. SPOONER,
323, High Holborn, London, Agent for the Applicant.

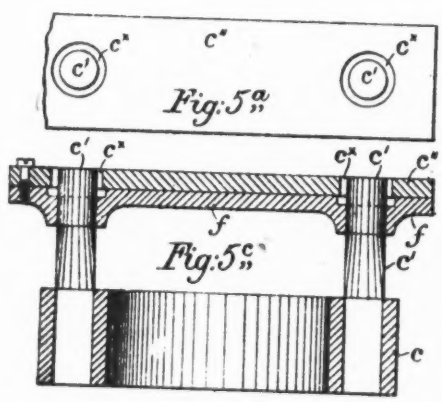
Redhill: Printed for Her Majesty's Stationery Office, by Malcomson & Co., Ltd.—1899.

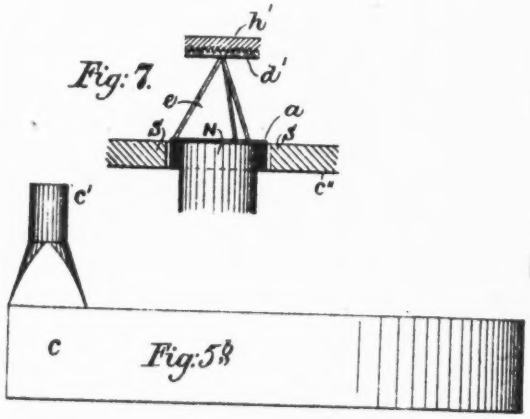


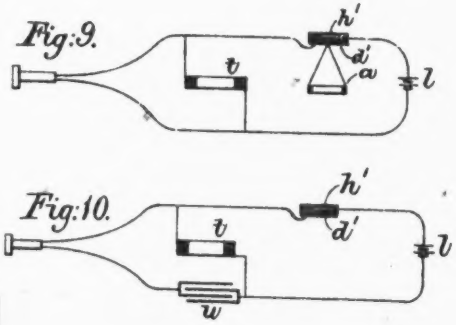


[This Drawing is a reproduction of the Original on a reduced scale.]

Malby & Sons Photo-Litho







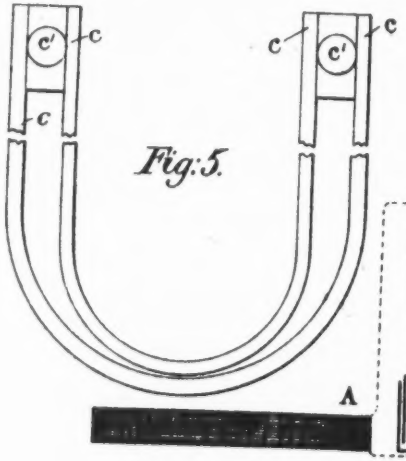
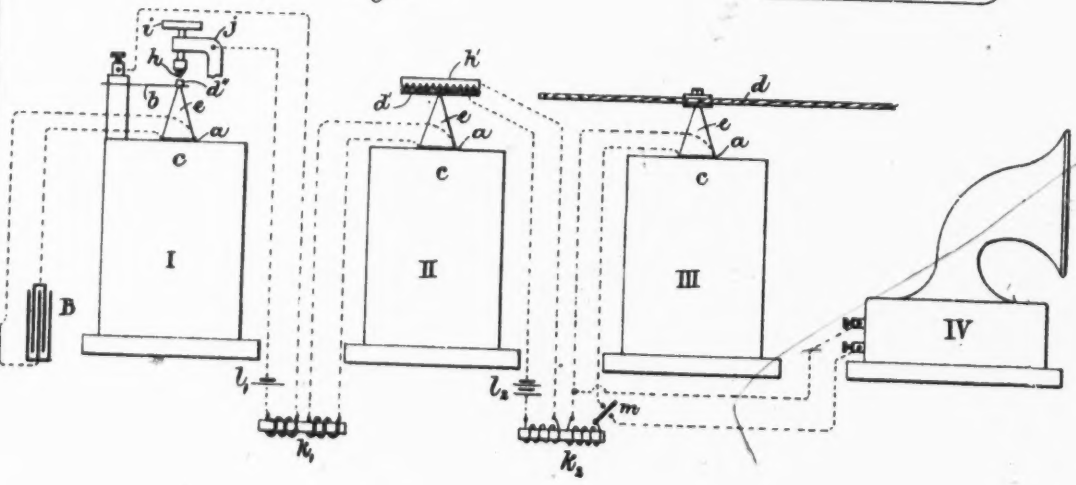


Fig:6.



[This Drawing is a reproduction of the Original on a reduced scale.]

Harrison & Sons, Photo-Litho 10 2

A.D. 1898. April 27. N.º 9712.
LODGE'S Complete Specification.

(3 SHEETS)
SHEET 3.

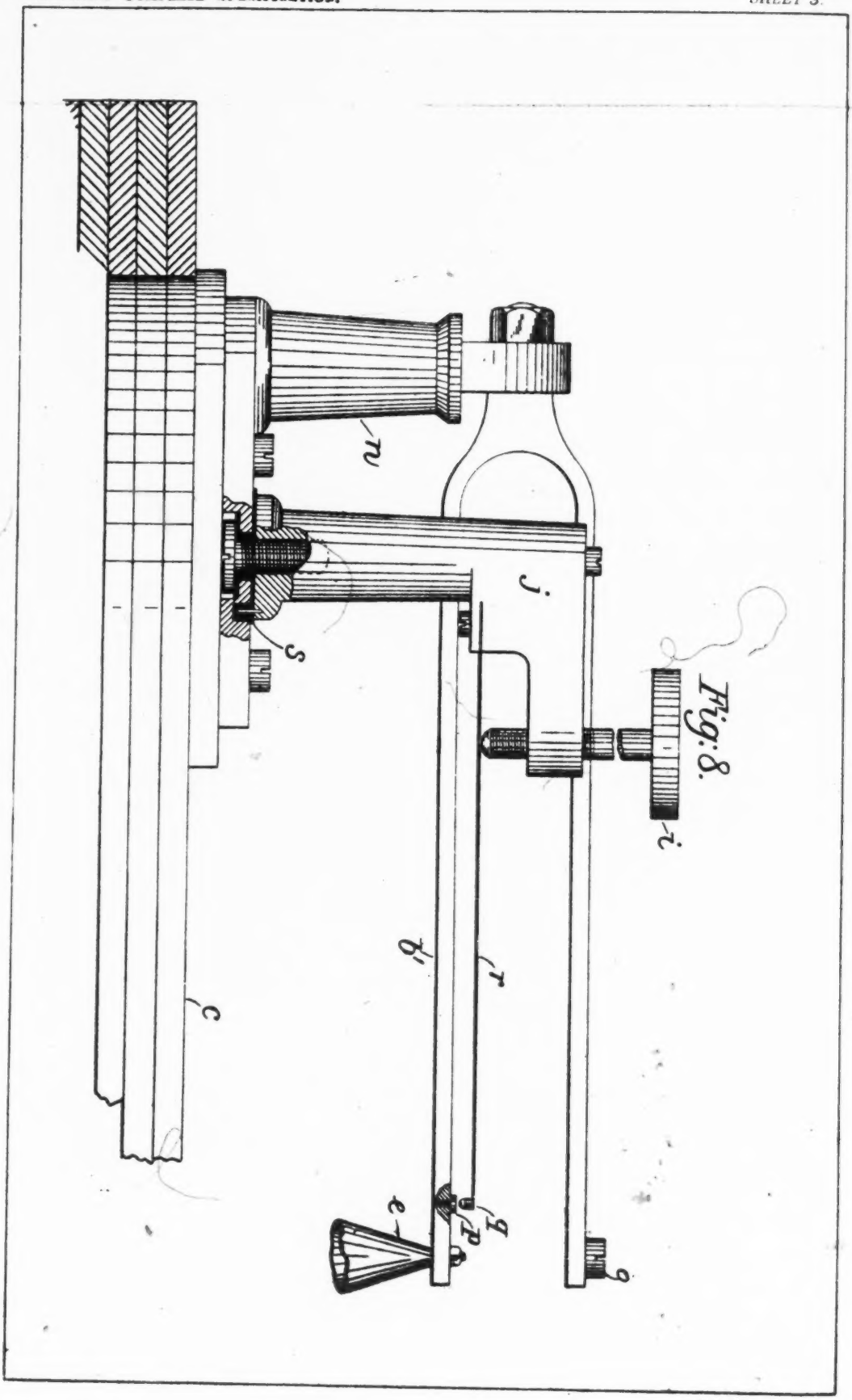


Fig. 8.

[This Drawing is a reproduction of the Original on a reduced scale.]

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THE "VIBRATOPHONE": A NEW PHONOGRAPH.

By Sydney G. Starling, B.Sc., A.R.C.Sc., F.Phys.S., and W. Cole, F.L.S.

We have devised a new form of phonograph which appears to be of sufficient scientific and general interest to merit a description in the pages of the Talking Machine News. The attachment was originally intended for use with a Pathé "Perfecta," and it is so simple that it may be made in half-an-hour at a cost of material that can only be reckoned in farthings.

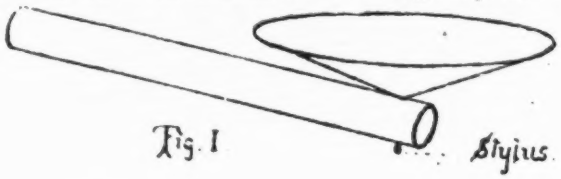


Fig. 1

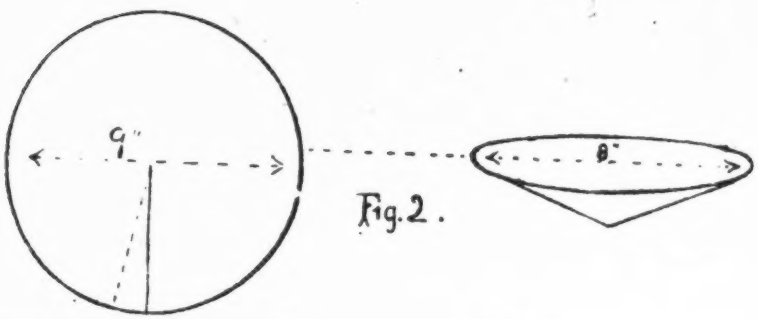


Fig. 2.

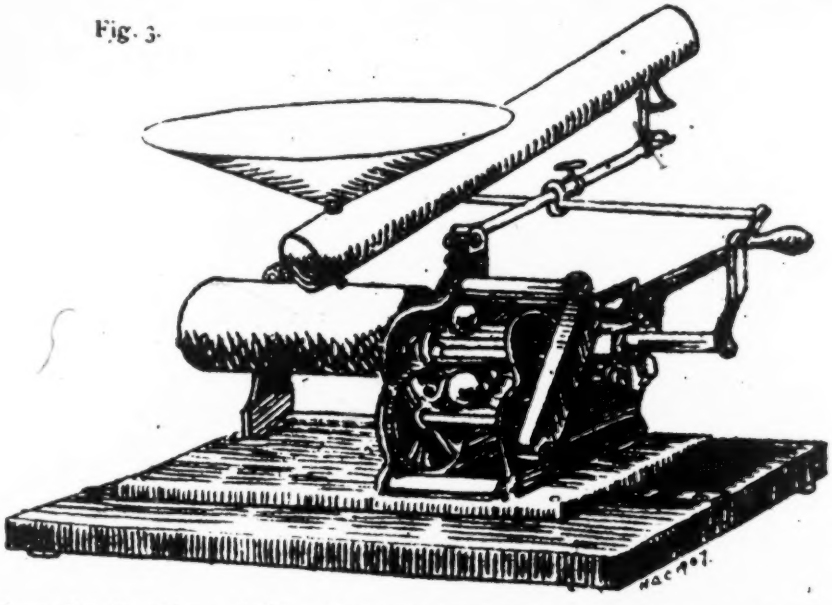
It consists of a low cone of cartridge drawing-paper 8 inches in diameter, and about 2½ inches high. This may easily be obtained by making a circle of the paper and cutting out a segment, as shown in Fig. 1, then bending the cone into shape, and securing with wax or cement. This paper cone is attached at the apex with wax or seccotine to a tube of millboard or cardboard, such as those sold by stationers for posting drawings and maps. This tube may be about 2 inches in diameter, and for fitting to the "Perfecta" it should be at least 12 or 13 inches long. The tube is open at both ends, and at the end immediately under the point of the paper cone, but, of course, on the opposite side of the tube, is fixed with wax or other cement a ball-stylus or sapphire. Our styli are made from thin rods of glass drawn out and fused in a spirit lamp, so as to form a thin thread of glass with a little spherical end, care being taken to get the ball of the right size, and with perfectly polished surface. A real sapphire stylus would doubtless be best.

Near the other end of the cardboard tube a hole is drilled to allow of the insertion and screwing fast of the little jointed rod by which the horn of the "Perfecta" phonograph is balanced on the guide-rod of the Orpheus attachment. The construction and mode of fixing up our device will easily be followed by an inspection of figures 2 and 3.

Some little judgment must be exercised in fitting up the apparatus to allow the tube to travel on the record from end to end without touching the wires of the Orpheus attachment.

Our object in the first place was to produce a diaphragm which should be large and rigid enough to set sufficient air in vibration to produce audibility without the intervention of a trumpet; our paper cone must be looked upon as a modified diaphragm and not in any sense a trumpet. It was intended in this way to avoid the distortion of the sound waves which

Fig. 3.



must occur in the cavity of the reproducer and horn, which cavity has such a complex shape that it is almost impossible that all the overtones of any note or sound should be reproduced with their intensities in the same proportion as in the original sound. In fact the cone in our arrangement behaves to the record and the style as the sounding board behaves towards a vibrating string. If the board is rigid and encloses no complex air space its vibration is a good copy of the vibration of the string; it merely serves to set more air in motion than the string alone could do. Thus our cone must have only sufficient curvature to give it rigidity. A perfectly rigid weightless plane would be an ideal form for the cone to take. The cardboard cylinder forms a convenient and efficient support for the cone, but whether it plays any acoustical part in the reproduction is an open question.

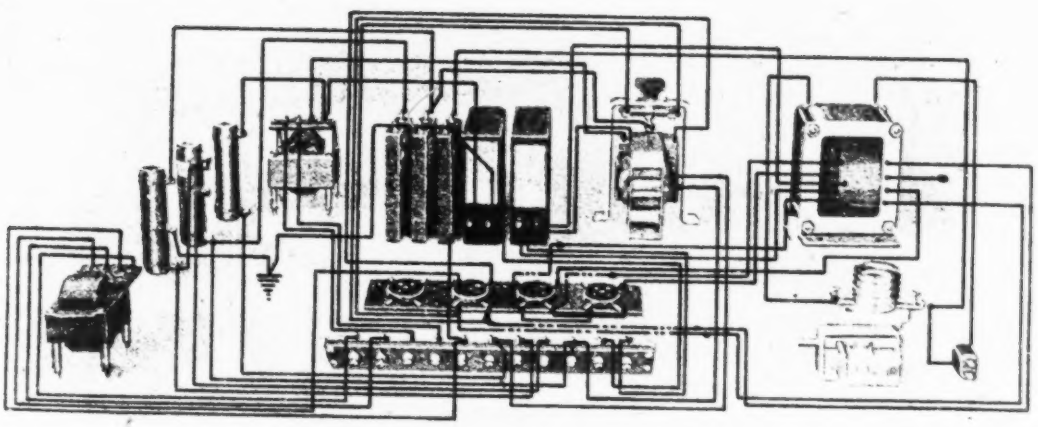
The sound, though much less intense than that produced by the ordinary method, is yet very pleasing and correct. The result is particularly good with low volume "home records," and to our ears the characteristics and timbre of the reproduction are pure and natural.

Although our experiments have been made with the "Perfecta" it would be easy to adapt the "Vibratophone" to other styles of machines. We appear to have selected roughly good sizes of cone and tube, still there is doubtless room for experiment in the selection of diameter and length. Celluloid and cardboard have been tried for making the cone, but in our experience paper is by far the best material.

The "Vibratophone" (to christen the little device) appears to have some practical uses beyond its scientific interest. It would serve excellently to try over records without disturbing others in the house when they need to be repeatedly played as in the study of folk-songs and language lessons by aid of the phonograph.

FORTHCOMING REDUCTION IN PRICE OF THE EDISON RECORD

DEFENDANT'S EXHIBIT NO. 27.
Service Bulletin No. 1, Victor Talking Machine Company, December 16, 1927.



Parts and Wiring of Power-Amplifier Units
AP-947-A, 951-A, and 997-A
(Used in 9-25 and 9-55)

DEFENDANT'S EXHIBIT NO. 28.
Service Bulletin No. 1, Victor Talking Machine Company, October 27, 1927.

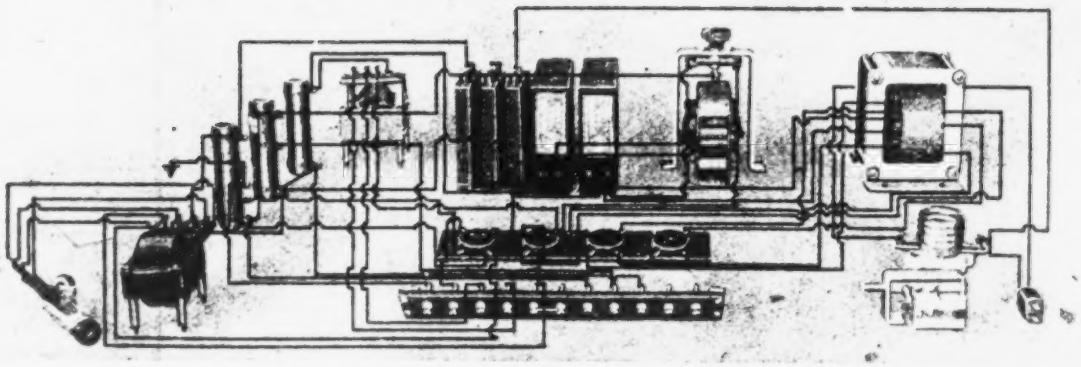
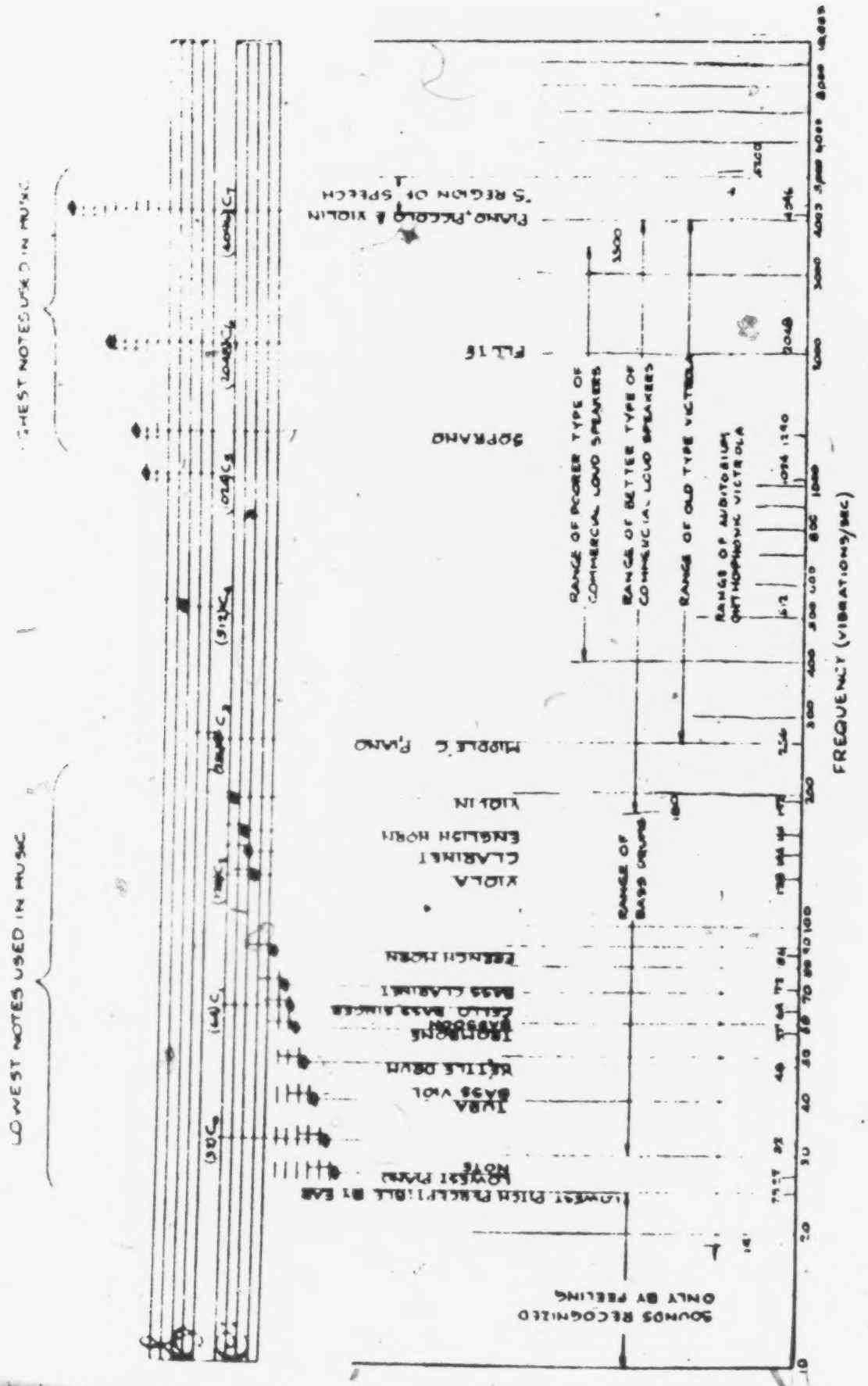


Fig. 8. Parts and Wiring of Power-Amplifier Unit AP 997 (RPA 5 Special)
(Used in 8-60)

DEFENDANT'S EXHIBIT NO. 38.
Chart of Frequency Vibrations of Music Notes.



W. O. WATTS & J. W. MAXWELL.
Mechanical Telephone.

No. 237,712. Patented Feb. 15, 1881.

Fig. 1.

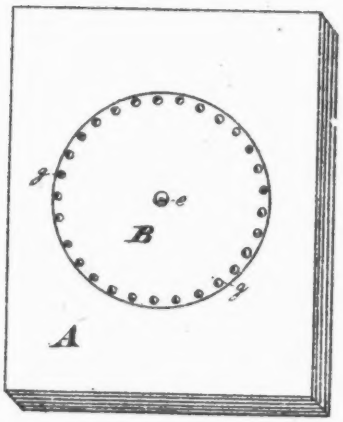


Fig. 2.

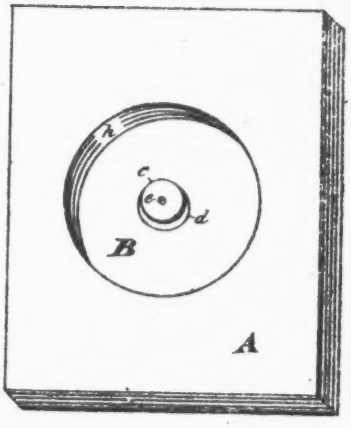
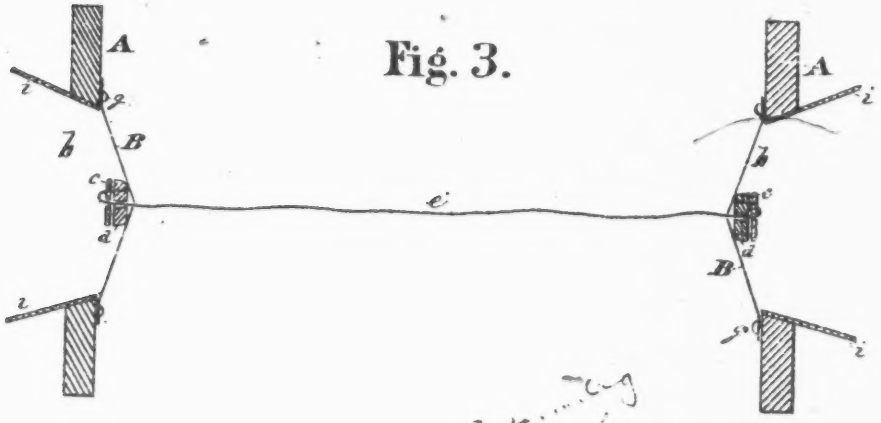


Fig. 3.



Witnesses:
A. H. Jackson
Wm. L. Jackson, Jr.

Inventor:
W. O. Watts,
J. W. Maxwell, by
A. M. Stout, their atty.

UNITED STATES PATENT OFFICE.

WILLIAM O. WATTS AND JOSEPH W. MAXWELL, OF LOUISVILLE, KY.

MECHANICAL TELEPHONE.

SPECIFICATION forming part of Letters Patent No. 237,712, dated February 15, 1881.

Application filed August 3, 1878.

To all whom it may concern:

Be it known that we, WILLIAM O. WATTS and JOSEPH W. MAXWELL, of Louisville, county of Jefferson, and State of Kentucky, have invented certain Improvements in Telephones, of which the following is a specification.

Our invention relates, generally, to an improvement in mechanical telephones or telegraphs designed for the transmission of articulate and other sounds to distant points; and it consists of the means and appliances hereinafter described, which accomplish the object by collecting, focalizing, and delivering vibrations upon a metal wire, which conducts them to the distant points and delivers them by devices exactly similar to those by which they were received.

Our invention consists, first, in the combination, in a mechanical telephone or telegraph apparatus, of a hollow conical or funnel-shaped diaphragm and a sound-conducting wire attached to and leading outwardly from its apex, as hereinafter more particularly described and explained; second, in the combination, in a mechanical telephone or telegraph apparatus, of two suitably-supported hollow conical or funnel-shaped diaphragms with a wire extending outwardly from and connecting their apexes; third, in the combination of a diaphragm, a conducting-wire extending through said diaphragm and having a button or enlargement at its end, and a washer interposed between the button and the diaphragm, all as hereinafter more fully described and explained.

In the accompanying drawings, Figure 1 is a rear view of the sound collecting, transmitting, and delivery apparatus. Fig. 2 is a front view of the same. Fig. 3 is a sectional view, showing a line-wire with one of our improved instruments connected to each end thereof.

A A are the sounding-boards; *b*, the circular openings in them. B B are the sound-developers; *e*, the conducting-wire; *c*, the buttons; *d*, the leather buffers, and *i i* the auxiliary tubes.

Of course the conducting-wire, when very long, must be supported at intermediate points to prevent sagging and swaying to and fro; but these are mechanical details which constitute no part of our invention.

The concave of each sound-developer is placed outward and is the front, and air-vibrations may be received in the concave of either and delivered from the concave of the other.

The wire *e* may be tightened and held taut by a device in the form of a common spool for thread having side bars attached to its flanges. To use it one end of the wire may be inserted through a hole in the stem or cylinder of the spool, and then the spool may be revolved until the wire is sufficiently taut, and then to hold it so another bar may be placed between these side bars and the wire itself.

Our theory of the operation of the parts of our improvement is that the material itself of the sounding-board, from its capacity of vibration, aids in producing the desired effect, and the form of the openings and the walls of the same have the like effect, and that the material of the sound-developer—sheep-skin, for instance—is quite important, on account of its hardness, smoothness of surface, and lightness, and its elasticity, and the protuberant or convex form is also highly important, as it serves to concentrate and focalize the vibrations together at about the same point on the wire, and has a similar effect upon the transmitted vibrations in delivering them to the ear of the hearer at the other end of the line with fidelity and distinctness. The funnel-shaped tubes *i i*, when used, will increase the efficiency of the other devices. They may be made longer or shorter than shown in the drawings, and their front ends may be flared more or less, as may be found desirable.

No extraneous force is used in the transmission of sounds by our apparatus, and we have found by repeated experiments that it will transmit several hundreds or thousands of feet not only articulated words with distinctness, but even the peculiarities of voice of the speaker, so that the voice may be recognized.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. The combination, in a mechanical telephone or telegraph apparatus, of a hollow conical or funnel-shaped diaphragm and a sound-conducting wire attached to and leading outwardly from its apex, substantially as described.

2. The combination, in a mechanical tele-

phone or telegraph apparatus, of two suitably-supported hollow conical or funnel-shaped diaphragms, with a wire extending outwardly from and connecting their apexes, substantially as described.

3. The combination of a diaphragm, a conducting-wire having a button or enlargement at its end, and the washer interposed between said button and diaphragm, substantially as and for the purpose set forth.

WM. O. WATTS.
W. MAXWELL.

Witnesses:
HENRY C. UNDERWOOD,
R. M. BUCKLEY.

DEFENDANT'S EXHIBIT No. 40.

W. H. DAVIS AND F. E. JOSS.
PHONOGRAPH TRANSMISSION.
APPLICATION FILED MAY 9, 1918.

1,312,958.

Patented Aug. 12, 1919.

2 SHEETS SHEET 1.

Fig. 1,

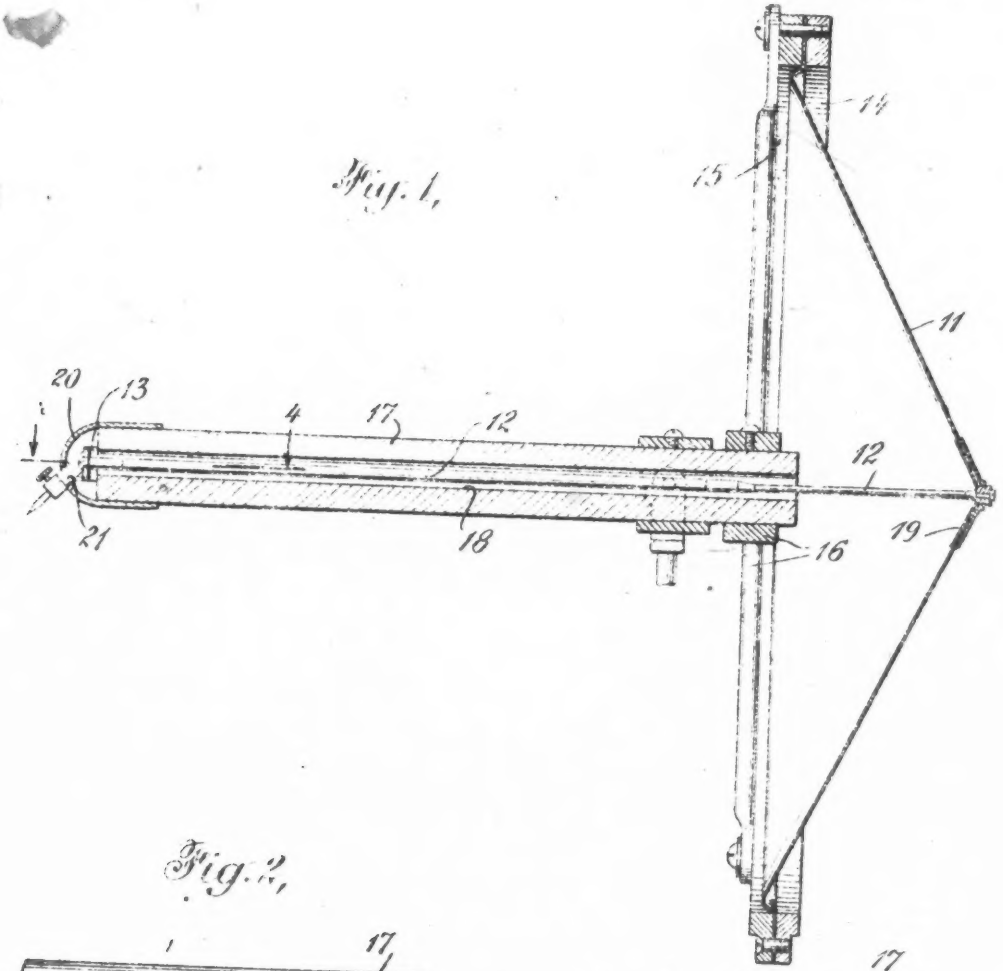


Fig. 2,

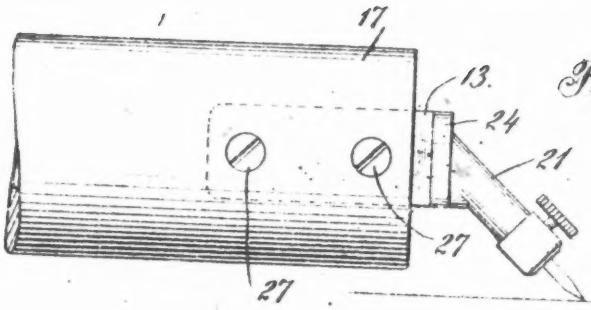
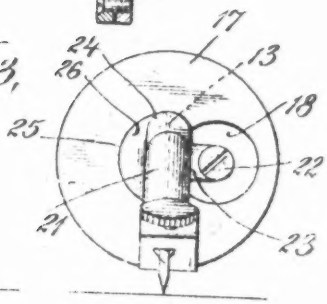


Fig. 3,



INVENTORS
William H. Davis & F. E. Joss
BY
Howson & Howson & Edmonds
ATTORNEYS

W. H. DAVIS AND F. E. JOSS.
PHONOGRAPH TRANSMISSION.
APPLICATION FILED MAY 9, 1918.

1,312,958. Patented Aug. 12, 1919.
2 SHEETS—SHEET 2.

Fig. 4,

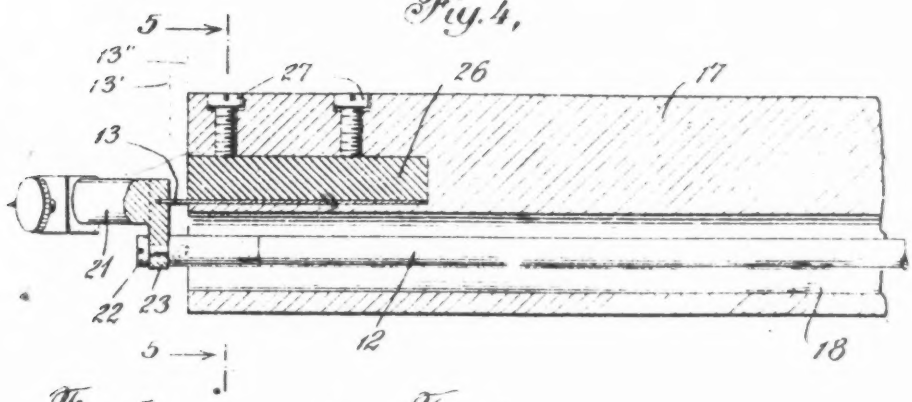


Fig. 5,

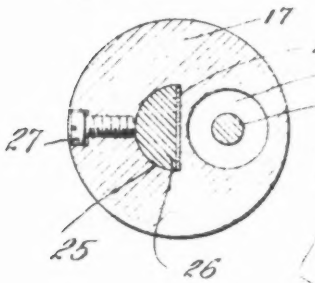


Fig. 6,

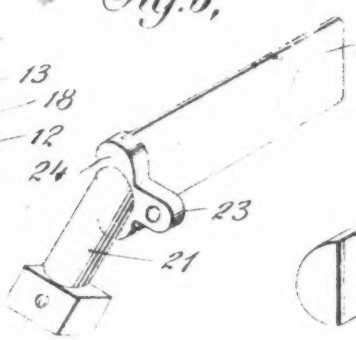
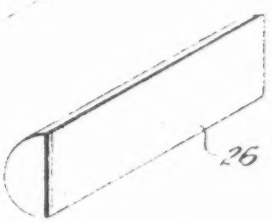


Fig. 7,



INVENTORS
William H. Davis & F. E. Joss
BY
Prouse, Davis, Marcus & Edmonds
ATTORNEYS

UNITED STATES PATENT OFFICE.

WILLIAM H. DAVIS, OF BRONXVILLE, AND FREDRICK E. JOSS, OF BROOKLYN, NEW YORK, ASSIGNORS TO LEKTOPHONE CORPORATION, A CORPORATION OF DELAWARE.

PHONOGRAPH TRANSMISSION.

1,312,935. Specification of Letters Patent. Patented Aug. 12, 1919.

Application filed May 9, 1918. Serial No. 233,466.

To all whom it may concern:

Be it known that we, WILLIAM H. DAVIS and FREDRICK E. JOSS, both citizens of the United States, residing at, respectively, Bronxville, county of Westchester, State of New York, and Brooklyn, county of Kings, city and State of New York, have invented certain new and useful Improvements in Phonograph Transmission; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to transmission mechanism particularly applicable in connection with sound reproducing or regenerating machines of the type disclosed in U. S. Letters Patent to Marcus C. Hopkins, No. 1,271,527 of July 2, 1918.

An embodiment of the invention is illustrated in the accompanying drawings; but it is to be understood that no limitation to the precise structural details thereof is contemplated, since the invention is manifestly susceptible of modifications and changes within its legitimate scope, as subsequently claimed, and it is also to be understood that parts of the invention may be used independently of, and separate from, other parts, and in other and different combinations and environments.

In said drawings:

Figure 1 is a vertical sectional view, taken axially of one type of stylus holder, diaphragm and connected parts;

Fig. 2 is an enlarged detail view, in side elevation, of certain of the parts shown in Fig. 1;

Fig. 3 is an end elevation of Fig. 2;

Fig. 4 is an enlarged, horizontal section taken on the line 4—4 of Fig. 1;

Fig. 5 is a transverse sectional view taken on the line 5—5 of Fig. 4;

Fig. 6 is a perspective view of the stylus holder and the spring carried thereby; and

Fig. 7 is a detail view similar to Fig. 6, showing the adjusting and clamping block associated with said spring.

The invention is shown as applied to or associated with a Hopkins-type diaphragm 11 and with a transmission rod or interponent 12. The essential feature of this embodiment of the invention is the provision of a spring connection between the transmission member 12 and the stylus holder 21, to effect the resilient support of the latter above suggested. This spring connection will be fully described hereafter, both as to its construction and arrangement and as to its action.

The diaphragm 11, referred to as a Hopkins-type diaphragm, is a sound regenerator of the kind disclosed by Marcus C. Hopkins in his above mentioned U. S. Letters Patent No. 1,271,527, to which reference may be had for a complete description of the said diaphragm. For all present purposes it is sufficient to state that the diaphragm comprises a conical portion of light, vibratile material, which portion, when vibrated from or by a record or other sound-vibrated element, is thereby enabled to produce self-sustaining sound waves of the same intensity as the original sound waves, so that it takes the place, not only of the old sound-box, but also of the usual accompanying horn or like amplifier. The diaphragm is rigidly supported at its periphery between a pair of clamping rings 14 and 15, which are fastened together by screws, or in some other suitable manner, and are carried by a spider 16, the hub of the latter being mounted upon one end of a tubular supporting bar 17. This bar is formed with an eccentric bore 18, extending therethrough from end to end and providing a passage through which the vibration-transmission rod or interponent 12 is inserted. The opposite ends of the rod project beyond the bar 17, the rear end of said rod being equipped with a conical cap 19 which engages the apex of the conical portion of the diaphragm. The free or front end of the bar has fitted on it a cylindrical cap or sleeve 20, within which are accommodated the projecting front end of the transmission rod 12 and a portion of the stylus holder 21, the aforesaid end of the rod being here shown as connected to the stylus holder by means of a screw 22, which passes through a laterally-extending ear 23 on the holder and into the rod end. The end of the holder in which the stylus is actually received, projects outwardly through an aperture in the cap 20, as will be understood.

The spring 13, previously referred to, has the form of a strip or leaf, which, at its

forward end, is anchored in a vertical saw-cut provided in the elongated rear end or base 24 of the stylus holder, of which base the ear 23 is an integral part, the major portion of this spring being received, however, in a semi-cylindrical recess 25, formed in the forward end of the support and opening through the same. The spring fits against the flat wall of the recess and is retained in place by means of an adjustable clamping block 26 of semi-cylindrical shape, which is itself secured in position by screws 27, the arrangement of the said wall of the recess with respect to the supporting bar and the stylus holder being such that the plane of the spring normally coincides with, or passes through, the axis of the holder. The adjustment of the spring affords means for experimentally locating and establishing a particular and very precise resiliency in the exposed length of the spring which serves as a mounting for the stylus holder, and in this way enables the sensitiveness of the diaphragm to be controlled. It is merely necessary to loosen the hub of the spider 16, thereby freeing the diaphragm to move with the transmission rod, after which the spring is adjusted and the spider hub re-tightened.

It has been found by actual tests that a construction such as that just described permits the stylus holder to vibrate with marked freedom and yet in true response to the vibrations cut on the phonic lines of the record; that there is an entire absence of pivot-chatter, and of many other usually-present disturbing noises; and that said construction enables the stylus holder to transmit its vibrations through the interponent vibrator rod to the regenerating diaphragm in such a way that the latter functions with the maximum efficiency of which it is capable. It will be seen most clearly from Fig. 4 that the stylus holder 21, or said stylus holder in combination with the rod 12 if these two parts be very rigidly interconnected, may be considered a lever having a peculiar pivotal point. Just where this pivotal point is located, for any particular rocking movement of the lever during the time that the stylus is in motion, would be difficult to determine; but obviously such point is always somewhere in the exposed end of the leaf-spring 13 between the planes 13′ and 13″. In one sense, the pivot point is a variable one, and probably is constantly shifting, according as a vibration of one amplitude is succeeded by a vibration of a different amplitude.

Further description of the invention, its mode of operation, and its advantages is believed to be unnecessary in view of the foregoing, and is, accordingly, omitted. It may be stated, however, that the character of the recording of the sound-waves, i. e., whether hill-and-dale or lateral cutting is adopted, is immaterial, and to that extent the showing is to be considered as diagrammatic.

We claim:

1. In a phonograph transmission, the combination, with a supporting bar having a bore extending therethrough; of a diaphragm carried by said bar at its rear end; a stylus holder at the front end of the bar; a vibration transmission element extending through said bore and connected at opposite ends with said diaphragm and said holder; and a resilient member connecting said holder and the adjacent end of said bar to vibratably support the former.

2. In a phonograph transmission, the combination, with a supporting bar having an eccentric bore extending therethrough; of a diaphragm carried by said bar at its rear end; a stylus holder at the front end of the bar; a vibration transmission element extending through said bore and connected at opposite ends with said diaphragm and said holder; and a resilient member connecting said holder and the adjacent end of said bar to vibratably support the former, said member normally occupying a plane which passes through the axis of the holder.

3. In a phonograph transmission, the combination, with a supporting bar; of a diaphragm carried by said bar at its rear end; a stylus holder at the front end of the bar; a vibration transmission element disposed longitudinally of the bar and connected at opposite ends with said diaphragm and said holder; and a resilient member connecting said holder and the adjacent end of said bar to vibratably mount the former.

4. In a phonograph transmission, the combination, with a supporting bar; of a diaphragm frame adjustable along said bar at one end; a diaphragm mounted in said frame for adjustment therewith; a stylus holder at the other end of the bar; a vibration transmission element disposed longitudinally of the bar and connected at opposite ends with said diaphragm and said holder; and a resilient member connecting said holder and the adjacent end of said bar to vibratably mount the former; said member having an adjustable engagement with said bar to regulate the vibratory movement of the holder.

5. In a phonograph transmission, the combination, with a supporting bar having a bore extending therethrough; of a diaphragm frame adjustable along said bar at its rear end; a diaphragm mounted in said frame for adjustment therewith; a stylus holder at the front end of the bar; a vibration transmission element extending through said bore and connected at opposite ends with said diaphragm and said holder; and a resilient member connecting said holder and

the adjacent end of said bar to vibratably support the former; said member having an adjustable engagement with said bar to regulate the vibratory movement of the holder.

6. In a phonograph transmission, the combination, with a supporting bar having a recess in its front end; of a diaphragm frame adjustable along said bar at its rear end; a diaphragm mounted in said frame for adjustment therewith; a stylus holder at the front end of the bar; a vibration transmission element disposed longitudinally of the bar and connected at opposite ends with said diaphragm and said holder; and a resilient member having its body inserted in said recess and its outer end projecting beyond the bar end and anchored to the holder to vibratably support the same, said member being adjustably engaged in said recess to vary the effective length and consequent resiliency of its said outer end.

7. In a phonograph transmission, the combination, with a supporting bar having a bore extending therethrough and a recess in its front end; of a diaphragm frame adjustable along said bar at its rear end; a diaphragm mounted in said frame for adjustment therewith; a stylus holder at the front end of the bar; a vibration transmission holder extending through said bore and connected at opposite ends with said diaphragm and said holder; and a resilient member having its body inserted in said recess and its outer end projecting beyond the bar end and anchored to the holder to vibratably support the same, said member being adjustably engaged in said recess to vary the effective length and consequent resiliency of its said outer end.

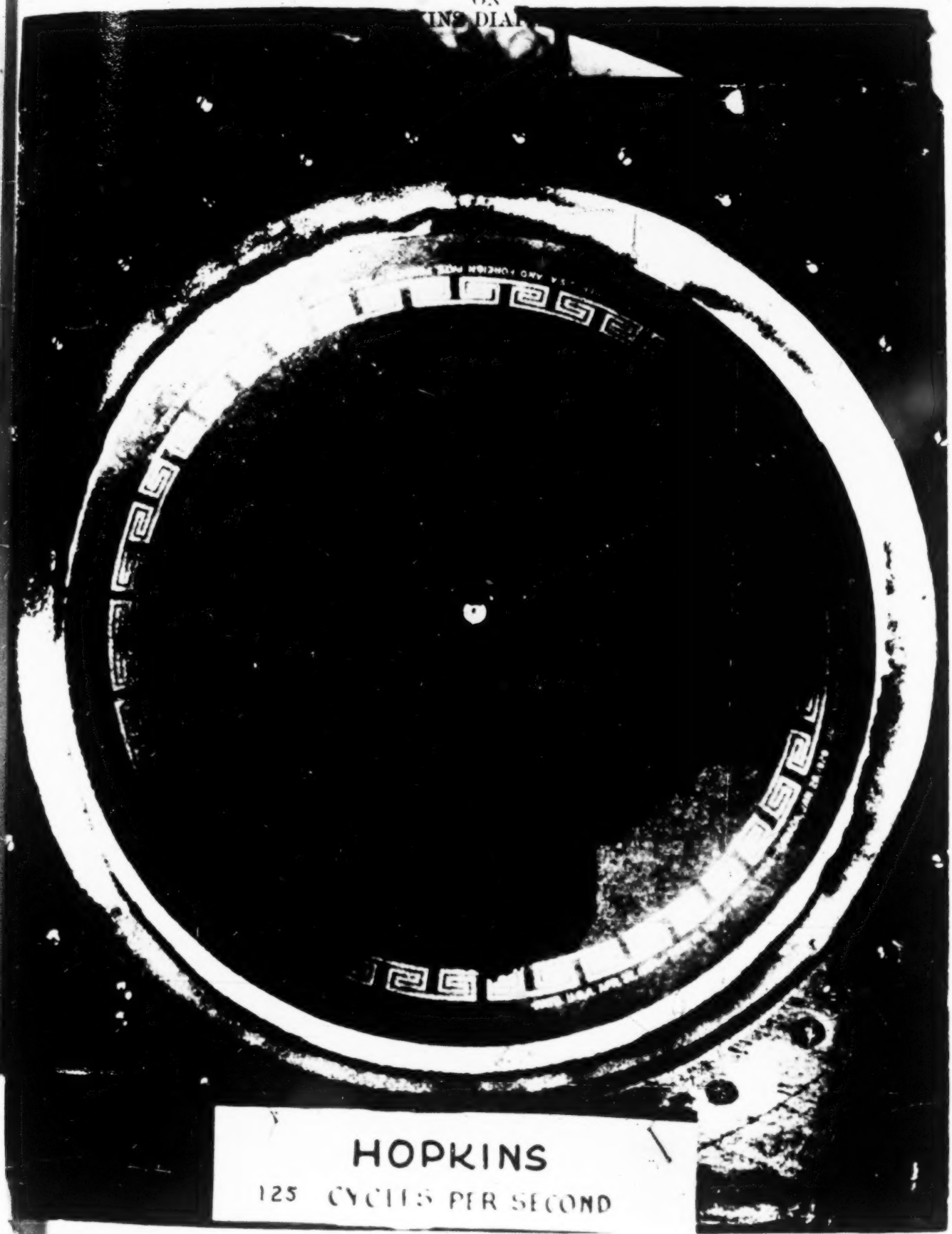
8. The combination of a supporting bar; a vibration transmission element disposed longitudinally thereof; a stylus holder at the front end of the bar having a base provided with a laterally-projecting ear to which the front end of the transmission element is connected; and a resilient member connecting said base and the front end of said bar to vibratably mount the stylus holder.

9. The combination of a supporting bar; a vibration transmission element disposed longitudinally thereof; a stylus holder at the front end of the bar having a base provided with a lateral projection to which the front end of the transmission element is connected, the rear face of the base being formed with a slot; and a leaf spring anchored at one end on said bar and at the other end in said slot to vibratably mount the stylus holder.

WILLIAM H. DAVIS.
FREDRICK E. JOSS.

DEFENDANT'S EXHIBIT NO. 41.

PHOTOGRAPHS OF SAND PATTERNS
ON
IN[illegible] DIA[illegible]



HOPKINS
3200 CYCLES

Dominion of Canada.

PATENT OFFICE.

Certified to be true and correct copies of the original specification and drawings remaining on record in this office, duplicate copies of which were attached to Patent No. 266,986 bearing date the 21st. day of December, 1926, and granted to Hopkins Corporation, assignee of Marcus C. Hopkins,

for "Loud Speaker",

(Application for which was filed March 9, 1926.)

The full fee for a term of eighteen years has been paid on said Patent

As Witness the seal of the Patent Office hereto affixed at the City of Ottawa, in the Dominion of Canada, this 20th day of 1928 in the year of our Lord one thousand nine hundred and twenty-eight.

Commissioner of Patents

Patent No. 256936
Dated Dec. 21, 1926
Filed Mar. 9, 1926

2½----------2
20-4-28
M.E.G.-------- M.S.

S P E C I F I C A T I O N

M.S.
M.E.G.

TO ALL WHOM IT MAY CONCERN:

Be it known that I, MARCUS C. HOPKINS, a citizen of the United States, residing in Washington, District of Columbia, whose post office address is care of D. Ballauf, Inc., 621 H. Street, N.W., Washington, District of Columbia, U.S.A., an Engineer, have invented certain new and useful improvements in

"LOUD SPEAKER"

and I do hereby declare the following is a full, clear and exact description of the same.

The present invention relates to loud speakers suitable for use with radio receiving sets, or as announcers for telephones and like wired circuits. It is an object of the present invention to improve the operation and appearance of loud speakers of the cone type by reinforcing or covering portions of the structure with paper, or other fibrous material, as hereinafter explained in detail. Other objects and advantages will become clear from the following detailed description taken in conjunction with the accompanying drawings, wherein

Figure 1 is a front elevation of a loud speaker of the cone type;

Figure 2 is a rear elevation of the same;

Figure 3 is a side elevation;

Figure 4 is an enlarged section on the line 4-4 of Figure 1;

Figure 5 is a front elevation of a modified form of speaker, and

Figure 6 is a section on the line 6-6 of Figure 5.

In the embodiment illustrated in Figures 1 and 4, inclusive, the loud speaker embraces a fibrous vibratory cone 1 which may be made from a flat sheet of cover paper cut and folded to shape and glued along a radial seam. Vibratory energy is delivered to the apex of this cone through a vibratory metal rod 2 clamped to the apex of the cone at 3 and vibrated by an electrical movement 4 secured to a wood cross arm or spider 5. At the base of the cone the paper is bent to form an outwardly flaring frusto conical brim 6. The base of the cone may be circular in outline, or it may be oval, as shown in Figure 1. Surrounding the

cone is an annular resonator 7, preferably made of wood, and having its inner beveled edge 8 glued or otherwise suitably secured to the outwardly flaring brim 6 of the cone. It is desirable that the brim shall overlap the wood edge far enough to give flexibility to the paper structure, ... in other words, to form a sort of hinge at the base of the cone for reasons explained at some length in my Canadian Patent No. 169,043, dated April 25, 1916 and my United States Patent No. 1,271,529, dated July 2, 1918.

The wood resonator can conveniently be made of three ply veneer with the grain of the inner ply running transverse to the grain of the two outer plies. Fir and spruce may be used for this purpose with satisfaction. Flued or otherwise suitably secured to the front face of the resonator 7 is a hollow anaglyph 9 shaped to give ornamentation, as indicated by Figure 1. Such an anaglyph can be made from long fibred paper stock by molding under pressure while damp. Such paper pulp anaglyphs are obtainable in the open market and are very light in weight, tough in texture, and with a surface dense enough to admit of artistic decoration. A thickness of 1/16th of an inch is suitable, but variations from that thickness may be made without radically changing the sound producing qualities of the loud speaker.

The structure above described may be mounted between wood pedestals 10 and 11, and a connecting cross bar 12.

The structure above described may be made in various sizes, but the one from which Figures 1 to 4 was made has a resonator approximately 24 1/2" high and 20 1/2" broad, and 3/8" thick.

When speech current is delivered from a radio receiving set, or from a telephone circuit, to electrical

movement 4, the variations of the speech current cause corresponding vibrations in the transmission rod 2, with the result that vibratory energy is delivered to the apex 3 of cone 1. The vibratory energy is then transmitted outward along the paper cone toward the wood resonator. Tones of high pitch travel along the paper for but a short distance before they are damped off by the air and become audible. Vibrations of middle pitch travel further along the cone but ultimately reach an area or annular zone at which they too are damped off by the air and become audible. Vibrations of the lower frequencies travel to the base of the cone and then through the paper hinge to the wood resonator and out toward or even to the edge of that resonator, and somewhere along that route, except for the lowest tones, will find a zone or annular area at which they too will be damped out by the surrounding air and will be dissipated as audible energy or sound.

The annular wood rim is not resonant in the sense that a tuning fork, or metal bell, or organ pipe, is resonant, for it has no capacity for prolonging the delivery of vibratory energy after the impelling force ceases. The wood rim, is, however, resonant in the sense that it acts as a sounding board for effectively delivering to the surrounding air the vibratory energy necessary to produce audible sound, and particularly, low tones. Phonetically it is dead beat.

The distribution throughout the structure of the vibratory energy delivered by rod 2 to the apex 3 of the paper cone depends on various factors, such as the weight, the stiffness, and the elasticity of the cone and of its

wood sounding board and the relation of these factors to the weight and elasticity of the surrounding air. That is to say, the radial distance through which vibratory energy of a given pitch will travel along the paper path and the paper and wood path depends on various factors, some of which are controllable. For all frequencies within the audible range there is a responsive annular band or area on the cone or its resonator. These responsive bands or areas overlap somewhat and the exact breadth and location of each band can be altered by changing the thickness of the paper cone, the slope of the cone, the magnitude of the vibratory movement imparted thereto by rod 2, etc. The responsive band for any frequency can be located by known laboratory methods.

I have discovered that with a structure constructed as above described, the face of the wood resonator may be covered with a hollow paper anaglyph without destroying the utility of the device as a loud speaker and even with an improvement in its tone characteristics through redistribution of the annular bands or areas which are responsive to the audible tones most desired from a loud speaker of this kind. It might be assumed that the application of a hollow paper anaglyph to the front face of the wood sound board would muffle or suppress the lower tones, but from experimental trial I have determined that there is not that disadvantage, and that whatever redistribution of sounding areas may have occurred in no way impairs the effectiveness of the device.

A hollow paper anaglyph glued in place as shown in Figs. 1 and 4 gives to the structure a highly ornamental effect. The anaglyph may be painted, or otherwise decorated,

of may be bronzed or gilded.

In the embodiment illustrated in Figures 5 and 6, a paper cone 13 actuated by an electrical movement 14 through a vibratory rod 15 attached to the cone apex 16 has a forwardly bent brim 17 glued for a part of its width to the inner beveled edge of the wood resonator or sound board 18.

With a cone made of cover paper and having a diameter of 17" at the base, the resonator 18 may properly have a diameter of four feet. When made of three ply spruce or fir the results are satisfactory. I find that there is advantage in stiffening the edge of such a resonator as by nailing thereto a relatively broad reinforcing wood rim 19. Claims on this rim when used independently of the other features herein disclosed are presented in a companion application. The rim 19 seems to have the effect of assisting in the translation into audible sound of vibrations of very low pitch which have traveled radially from the apex of the cone to the periphery of the annular resonator 18. A second rim 20 of wood may be secured within rim 19 and may be given an ornamental finish by a molding 21. There is advantage in having rim 20 and molding 21 hollowed out as shown in the drawing, though just why this is I am not at the moment prepared to state unless it be the lightening in weight thereby obtained. A wood beading 22 glued or tacked to the front of the resonator improves its appearance. Such a beading can also be used to regulate distribution of the responsive bands or areas, and can be shifted in position until by experimental trial the desired result is produced.

In this embodiment two hollow paper anaglyphs 23 and 24 are used in a concentric grouping as shown in Figure 5. Omitting one or the other will change somewhat the distribution of the sounding bands or areas, and the use of

supplement anaglyphs of larger diameter will likewise influence distribution of the sounding areas. However, with a 4 foot resonator of three ply fir 3/8" thick and a central opening 17" in diameter and fitted with a cone of cover paper as above described, the number, size and distribution of anaglyphs, the beading 22, and the rims 19 and 20 may be advantageously as shown in Figures 5 and 6. Such a structure finished throughout in imitation of antique bronze presents a pleasing dignified appearance when supported vertically, or when suspended in horizontal position below the ceiling of an auditorium. It is intended for use in rooms of relatively large capacity, such as theatres, restaurants, dance halls, and the like.

I CLAIM:-

1. In a loud speaker having a resonator, and an anaglyph secured to and covering a part at least of said resonator.

2. In a loud speaker having a resonator, an attached hollow paper covering for a part at least of said resonator.

3. In a loud speaker having a wood resonator, a hollow paper covering secured to and covering a part at least of said resonator.

4. In a loud speaker, the combination of a paper cone, a sounding board therefor, a yielding connection between said cone and said sounding board, and a paper anaglyph secured to the front face of said sounding board.

5. In a loud speaker, the combination of a fibrous vibratory cone, a wood sounding board operatively connected to the periphery of said cone, and a hollow paper anaglyph secured to the front face of said resonator.

6. In a loud speaker, the combination of a fibrous vibratory cone, a wood resonator operatively connected to the periphery of said cone, and a hollow paper anaglyph secured to the front face of said resonator.

7. In a loud speaker, the combination of a paper cone having a forwardly bent brim, a resonator to the beveled inner edge of which said brim is secured, and a hollow paper anaglyph glued to the front face of said resonator.

8. In a loud speaker the combination of a fibrous vibratory cone having a forwardly bent brim, a wood resonator operatively attached to said brim, a wood rim secured to and stiffening the edge of said resonator, and a hollow paper anaglyph secured to the front face of said resonator.

9. In a loud speaker the combination of a paper cone having a forwardly bent brim, a resonator to the beveled inner edge of which said brim is secured, a rim secured to and stiffening the edge of said resonator, and a hollow paper anaglyph secured to the front face of said resonator.

10. In a loud speaker the combination of a fibrous vibratory cone having a forwardly bent brim, an annular resonator to the beveled inner edge of which said brim is glued, a wood rim secured to and stiffening the edge of said resonator, and a hollow paper anaglyph glued to the front face of said resonator.

IN TESTIMONY WHEREOF I affix my signature, in the presence of two witnesses at Washington, D. C., this 20th day of February, 1926.

(Sgd). MARCUS C. HOPKINS

RICHARD K. STEVENS

GORDON C. MACK

Loud Speaker. 2666936

1 (2)

Fig. 1,

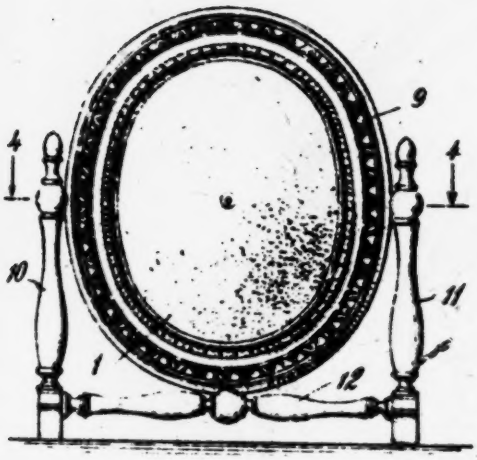


Fig. 2,

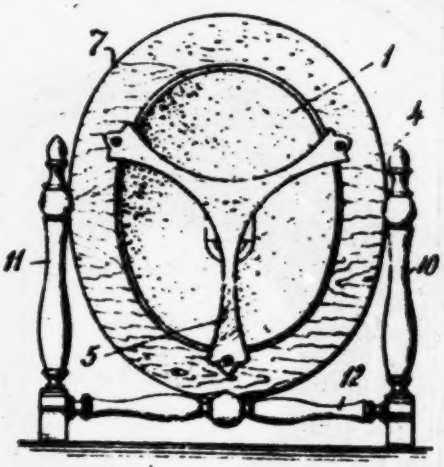


Fig. 3,

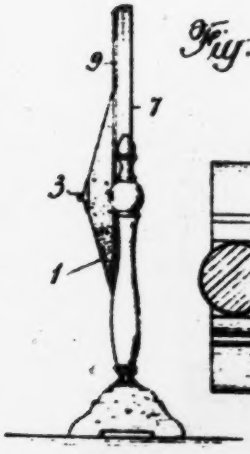
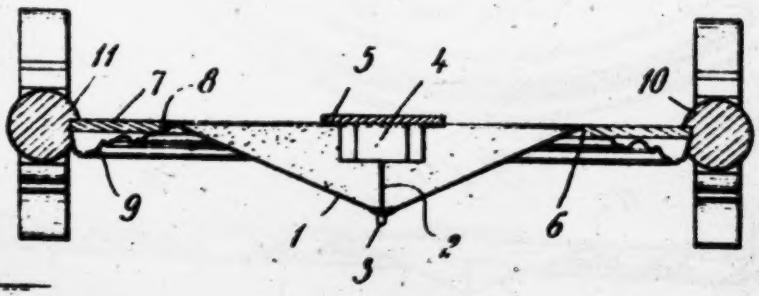


Fig. 4,



Certified to be the drawing referred to in the specification hereunto annexed.

New York, N.Y. Feb'd. March 8 1926

APPLICANT

Marcus C. Hopkins

By Pennie, Davis, Marvin & Edmonds

ATTORNEY

570

266936
2(2)

Fig. 5.

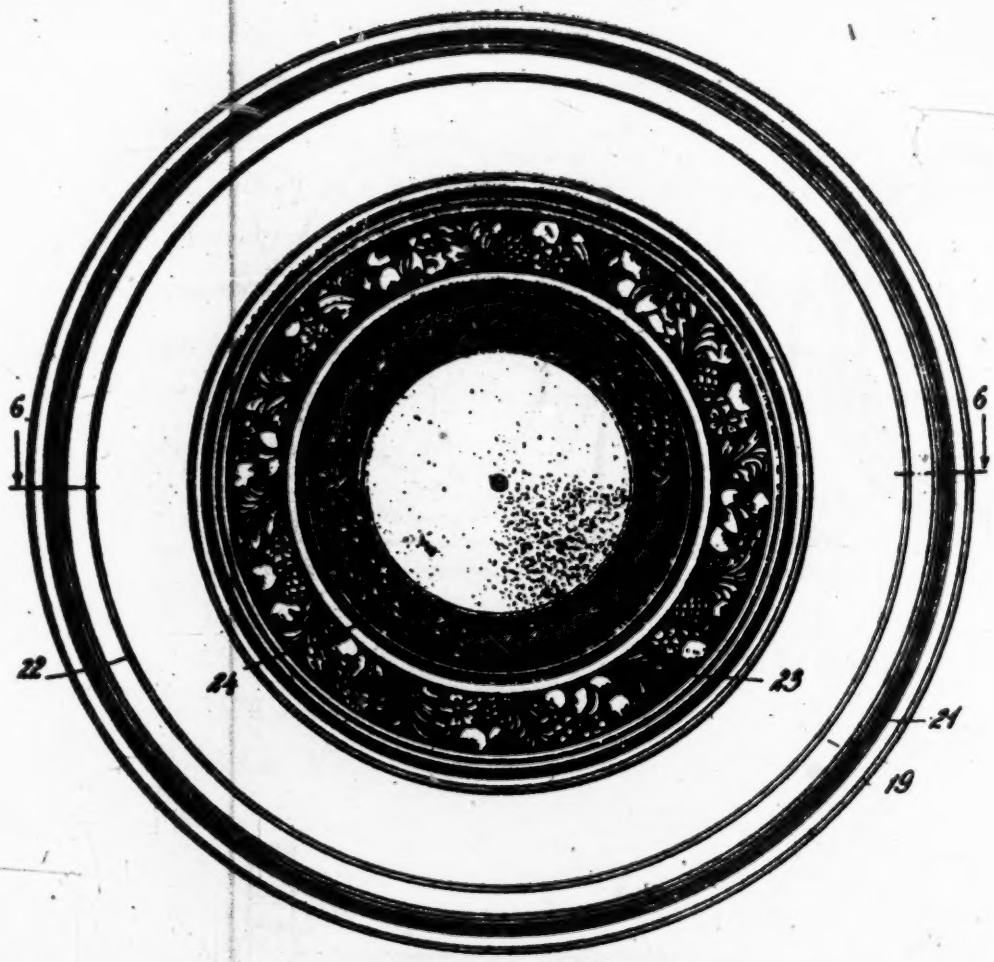
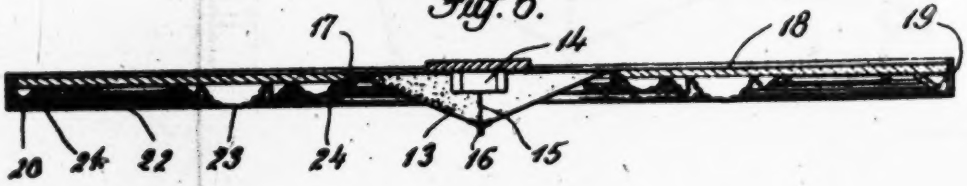


Fig. 6.



Certified to be the drawings referred to in the specification hereunto annexed.

New York, March 2, 1926

APPLICANT

Mariano R. Olivieri

Per Pennie, Davis, Marvin & Edmonds

ATTORNEY

DEFENDANT'S EXHIBIT NO. 44.

571

Dominion of Canada.

PATENT OFFICE.

Certified to be true and correct copies of the original specification and drawings remaining on record in this office, duplicate copies of which were attached to Patent No. 266,984 bearing date the 21st day of December, A 1926, and granted to Hopkins Corporation, assignee of Marcus C. Hopkins,

for "Loud Speaker",

(Application for which was filed March 9, 1926.)

The full fee for a term of eighteen years has been paid in said Patent.

As Witness the seal of the Patent Office hereto affixed at the City of Ottawa, in the Dominion of Canada, this 20th day of April, in the year of our Lord one thousand nine hundred and twenty-eight.

H. Lalonde

Patent No. 266934
Dated Dec. 21, 1926
Filed Mar. 9, 1926

3----------4

19-4-28

M.R.....A.M.

S P E C I F I C A T I O N.

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, MARCUS C. HOPKINS, a citizen of the United States, residing in Washington, District of Columbia, whose post office address is care of D. Ballauf, Inc., 621 H. Street, N.W., Washington, District of Columbia, U.S.A., an Engineer, have invented certain new and useful improvements in

"LOUD SPEAKER"

a.m.
m.k.

and I do hereby declare the following is a full, clear and exact description of the same.

The present invention embraces a loud speaker suitable for use on a radio receiving set, and also suitable for use as an annunicator on wired radio systems, and in general, wherever speech current is to be translated into audible sound.

It is an object of the present invention to provide a loud speaker of the cone type wherein the cone, which may be made of paper or like material, has its outer edge bent forward to form a brim or rim by which the cone is yieldingly attached to a wood frame capable of acting as a resonator to supplement the sound-producing action of the cone.

In the preferred form of the device the wood frame is of circular outline and has cut in one of its faces an annular groove bordered by beveled edge to which the brim of the cone can be glued or otherwise secured. That portion of the disc outside of the cone acts as a sound producer or resonator, and that part of the disc within the periphery of the cone acts as a mechanical support for the electrical movement whereby the device is actuated.

Other objects and advantages will become clear from the following detailed description taken conjunction with the accompanying drawings wherein

Figure 1 is a front elevation of the loud speaker;

Figure 2 is a side elevation of the same;

Figure 3 is a sectional elevation on the line 3-3 of Figure 4;

Figure 4 is a front elevation with the paper cone removed to disclose the electrical movement;

Figure 5 shows the electrical movement in front elevation with certain parts in section;

Figure 6 shows said element in side elevation;

Figure 7 is a transverse section on the line 7-7 of Figure 5;

Figure 8 is a plan view of the electrical movement;

Figure 9 is a sectional detail of the laminated armature thereof,

Figure 10 shows the slots in the adjustable pole shoe of the unit, and Figure 11 is a detail of one of the pole pieces.

The preferred embodiments disclosed in the drawings comprise a wood base 1 having a slot in which is glued the lower edge of a circular resonator 2. This resonator is preferably made of three ply wood. Three ply fir three eighths of an inch thick is suitable, and there is advantage in having the grain of the inner ply 3 disposed at right angles to the grain of the two adjacent outer plies. An annular groove 4 is turned in this resonator, and at the outer edge of this groove the wood is beveled at 5 to form a seat to which may be glued the outwardly bent brim 6 of the sound producing cone 7. This cone may be made of paper. Paper of the quality known as cover paper is suitable. The cone can be cut from a flat sheet and then bent into shape and glued along a radial seam. The outer edge of the conical structure so formed is then bent at 8 to form an outwardly flaring brim. The brim will naturally take on a fruste conical form making an angle to the vertical plane substantially equal to the angle at which radial elements of the cone intersect the vertical plane. It is important that the outer part only of this brim 6 be fastened to the wood resonator at the beveled surface 5 for the inner portion of the brim is relied on to form a resilient support or hinge whereby the cone 7 may move

bodily without substantial distortion. For a paper cone 12" in outside diameter the brim may be 3/8 of an inch wide and the glued portion may have a width of 1/4" or thereabout.

The cone plays, not only on its front surface, but also on its back surface, and to prevent muffling of its vibrations, there is advantage in cutting away a part of the wood disc 2 as by cutting three circular openings therein a, b and c as shown in Figure 4. This leaves a spider of wood strong enough to support the electrical actuating movement, but not obstructing the rearwardly projected sound waves to such an extent as would cause troublesome muffling. That part of the disc which lies outside of the cone is the part mainly relied on to supplement the primary vibrations of the cone, and to act as a sounding board, particularly for tones in the lower range, though some of that part of the board within the periphery also acts to transmit vibrations to the air.

The electrical movement for actuating the cone comprises a permanent magnet 9 suitably clamped to the wooden disc 2 as by a cross bar 10 and machine screw 11. Secured to pole 12 of the magnet by a screw 13 (Fig.5) is a pole piece 14 of irregular shape. This pole piece 14 is provided with an extension 15 which projects beyond the end of pole 12 and carries a pair of lugs 16 pressed out from the stock of the extension by a punching operation and serving to center the pole piece on the end of the pole when bolt 13 is tightened. The other magnet pole 17 is similarly provided with a pole piece 18 held in place by a screw 19 and carrying a transverse bolt 20 whereby the vibratory armature is supported.

The vibratory armature consists of a plurality of

blued steel laminations 21, say four in number, spaced apart on bolt 20 by iron washers 22, with which the laminations make close magnetic contact. At their other ends the laminations are spaced apart by soft iron washers 23, and are held in close contact therewith by a soft iron element 24, one end of which is riveted over to form an annular flange 25 tightly holding the laminations and washers together. This element 24 is in part hollow to receive a transmission rod 26, preferably made of phosphor bronze and secured to element 24 by solder 27. The forward end of the transmission rod 26 passes through a hollow rivet 28 at the apex of the cone, and may there be rigidly attached by a soldered connection 29 (Fig.5). Or, if desired, as shown in Figure 6, a set screw 30 may be used in place of or as supplemental to a soldered connection 31. Conical brass plates 32 and 33 serve to strengthen the apex of the cone and are held in tight engagement with the paper at the apex of the cone by the hollow rivet 28.

The electro magnet to which speech current is delivered for actuating the armature comprises a simple solenoid 34. About 6000 turns of No. 40 enameled wire mounted on a bakelite or composition spool 35 is suitable for this purpose. An insulating face plate 36 may be used as a guide and anchor for the leading in wires 37 and 38. Mounted to move within this coil is a soft iron pole shoe 39, a portion of which is threaded at 40 for engagement with threads cut in the pole piece 14. There is also provided a knob 41 positioned at the back of the wood resonator and by which pole shoe 39 may be advanced or retracted to increase or decrease the air gap between it and the opposing element 24. The pole shoe is

preferably provided with intersecting slots 42 and 43 (Fig. 10) to reduce eddy currents.

Figure 11 shows pole piece 14 in rear elevation. I find that it is advantageous to first drill this pole piece to receive the threaded pole shoe 39 and then to slot it at 44 through the tapped hole. The two fingers thus produced are then squeezed inward toward one another by such an extent as may be needed to give a frictional grip on the threaded portion 40 of the pole shoe 39. This prevents that pole shoe from working loose during shipment and also holds the pole shoe in rigid position irrespective of the vibration to which the pole shoe is subjected when in actual use. This slot 44 has the further function of reducing eddy current losses in that part of the pole piece lying nearest to coil 34. This one expedient increases the effectiveness of the device to a very noticeable extent.

With the elements constructed and arranged as above described a speech current passed through winding 34, as from a radio receiving set or a wire annunciator system or circuit, will produce a corresponding vibration of the laminated armature and such movement of the transmission rod 26 as to translate the electrical impulses into audible sound thereby in effect reproducing the speech or other signal represented by the speech current.

The conical diaphragm 7 can move bodily because of its yielding or hinged connection with the wood resonator, and I have found is capable of transmitting its vibrations through the hinge to the wood. This is particularly true with respect to tones low in the musical scale. The wood takes up the vibrations and together with the cone transmits the

vibrations to the surrounding air with results that are highly satisfactory. The pole shoe can be advanced or retracted through coil 34 by suitably manipulating the knob 41, and in this manner the width of the air gap can be coordinated to the strength of the signals being received. Any expansion or contraction of the diaphragm due to atmospheric conditions is not of serious consequence because the free end of the armature can move with the cone and readjustment of the air gap to compensate for such changes requires nothing more than manipulation of knob 41.

The loud speaker or annunciator above described may be made in various sizes, and is compact, rugged, and inexpensive to build. When built into a radio receiving set or cabinet, or when used as an accessory in other articles of merchandise, such as reading lamps, the base 1 may be omitted.

Various changes in details of parts, and in their grouping may be made without departing from the spirit of the invention as defined by the appended claims.

In my copending application, Serial No.311,594 filed March 9, 1926 claims are presented on the broad expedient of shaping the paper cone with a bent brim and attaching this brim to a beveled seat on the resonator. Also in my copending application Serial No. 311,591 filed March 9, 1926 claims are presented on the electrical movement described above.

I CLAIM:

1. In a cone type loud speaker, the combination of a flat sounding board, and a cone flexibly connected thereto, said sounding board extending across the base of the cone.

2. In a cone type loud speaker, the combination of a sounding board of circular outline and a cone flexibly connected thereto, said sounding board extending beyond the periphery of the cone and having portions extending across the base of the cone.

3. In a cone type loud speaker, the combination of a flat sounding board of wood having holes therethrough near the center of the board, and a vibratory cone mounted on said sounding board outside of said holes.

4. In a cone type loud speaker, the combination of a flat sounding board having an annular groove and a vibratory cone mounted on the front face of said board with its edge in said groove.

5. In a cone type loud speaker, the combination of a wood sounding board having an annular groove, and a vibratory cone having its periphery positioned in said groove.

6. In a cone type speaker, the combination of a flat sounding beard having an annular groove with a beveled edge, and a vibratory cone having a forwardly bent brim glued to the beveled edge of said groove.

7. In a cone type speaker, the combination of a wood sounding board having an annular groove, and a vibratory cone flexibly secured to the front face of said board with its periphery positioned in said groove.

8. In a cone type loud speaker, a sounding board having openings therethrough to form a spider, a cone secured to the face of said board outside of said spider, and an actuating movement housed within said cone and supported by said sounding board near the center of said spider.

9. In a cone type loud speaker, the combination of a sounding board having an annular groove with a beveled edge, a vibratory cone flexibly secured to said beveled edge, and an actuating movement supported by said sounding board and operatively connected with the apex of said cone.

10. In a cone type loud speaker, a sounding board cut away near its center to form a spider, a paper cone of less diameter than said sounding board and having a forwardly bent brim secured to said sounding board outside of said spider, and an actuating movement supported by said spider and operatively connected to vibrate said cone.

11. In a cone type loud speaker, the combination of a wood back, an actuating movement carried thereby, and a cone supported at the front of said wood back and operatively connected to said movement.

12. In a cone type loud speaker, the combination of a plane wood back, a cone of lesser periphery yieldingly engaging the front face therof, and an actuating movement connected with said cone and housed between said cone and said back, said back being cut away in part to facilitate the propagation of sound from the rear of said cone.

13. In a cone type loud speaker, the combination of a wood base, a vertical wood back carried thereby and

having holes therethrough for the transmission of sound, an actuating movement supported on the front face of said back near its center, and a vibratory cone of lesser diameter than said back and covering the holes therein, and also covering said actuating movement, the apex of said cone being operatively connected with said actuating movement.

14. In a cone type loud speaker, the combination of a vertical wood back having sound transmitting openings therethrough, said back having an annular groove in the front face thereof outside of said openings, and a vibratory cone mounted for free bodily movement and having its periphery in said groove.

15. In a cone type loud speaker, the combination of a wood back having openings therethrough, an annular groove in the front face of said back outside of said openings, and actuating movement mounted on the front face of said board near its center, and a vibratory cone housing said movement and having its edge yieldingly connected with said wood back at said groove.

16. In a cone type loud speaker, the combination of a wood back having an annular groove in the front face thereof, a vibratory cone having its edge in said groove, and a yielding element between said edge and the wood of said groove.

17. In a cone type loud speaker, the combination of a wood back with sound transmitting openings therethrough an actuating movement supported on the front face of said wood back near its center, a paper cone of less diameter than said wood back and housing said actuating movement, and a yielding element between the edge of said cone and said back adapted to give physical support to the cone while

permitting bodily movement thereof when actuated on by said movement.

18. In a cone type loud speaker, the combination of a flat wood back, an actuating movement carried thereby, a cone supported at the front of said wood back with its concave side toward said back, said back extending beyond the periphery of the cone and having portions extending across the base of the cone.

19. In a cone type loud speaker the combination of a plane back of wood veneer, a cone of lesser periphery with its edge spaced from said back by an annular yielding element and an actuating movement operatively connected between said cone and housed between said cone and said back, said back being cut away in part within the periphery of the cone.

20. In a cone type loud speaker, the combination of a wooden sounding board, a conical diaphragm mounted thereon and actuating means connected to the diaphragm, at least a portion of the sounding board extending across the base of the cone.

IN TESTIMONY WHEREOF, I affix my signature, in the presence of two witnesses at Washington, D.C., this 20th day of February, 1926.

(Sgd.) MARCUS C. HOPKINS.

RICHARD K. STEVENS.

GORDON C. MACK.

Loud Speaker 266934

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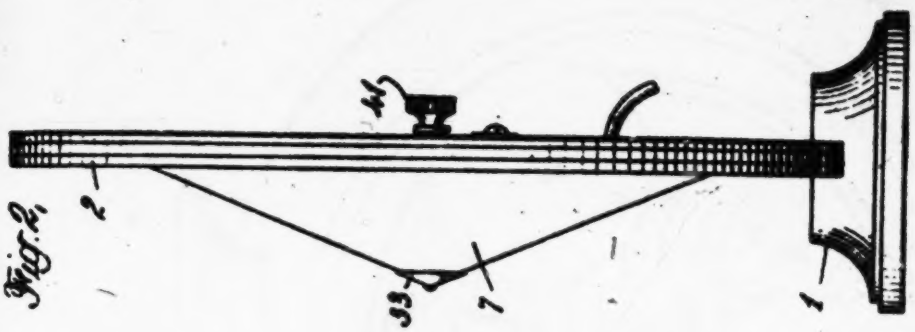

Fig. 2.

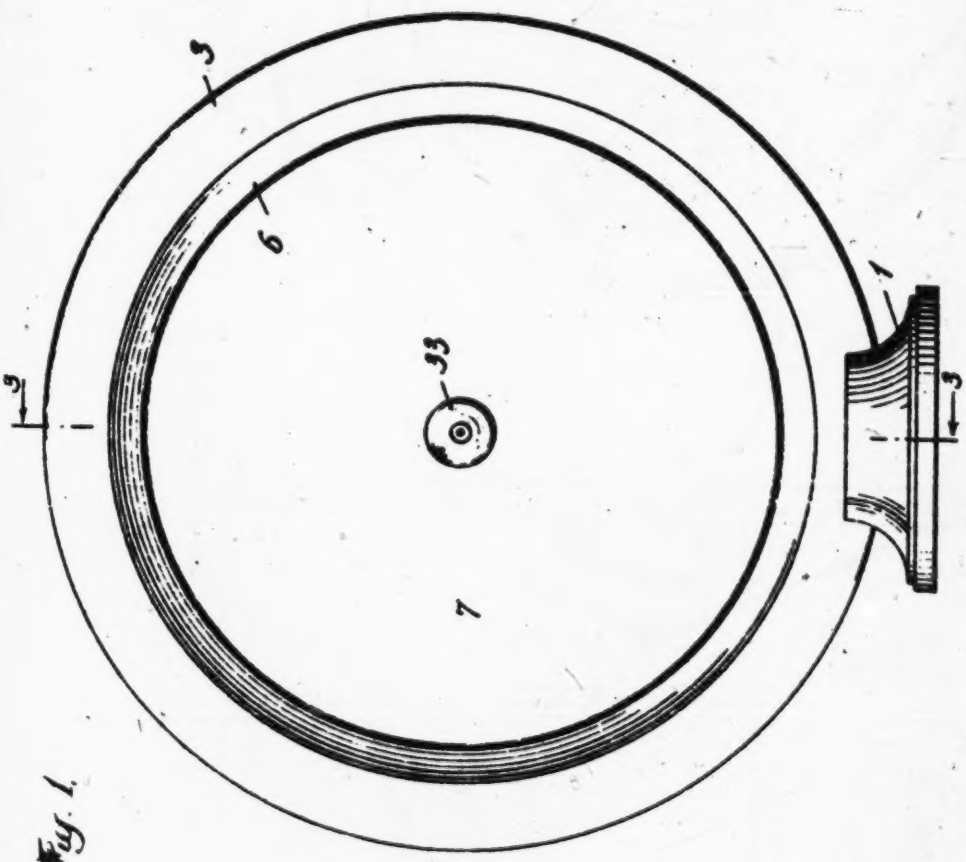

Fig. 1.

Certified to be the drawings referred to in the specification hereunto annexed.

New York, N.Y. U.S.A. March 8, 1926

APPLICANT

Marconi C. Wireless

By Symes, Davis, Maxwell & Edmonds

ATTORNEY

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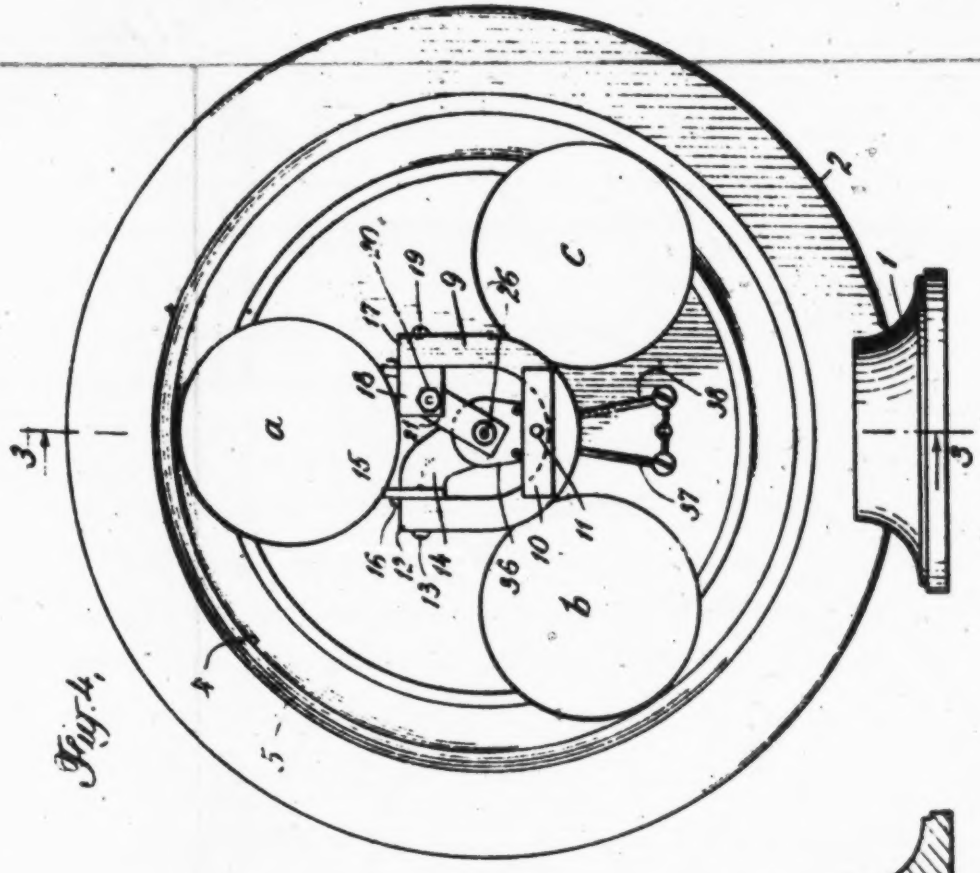

Fig. 4.

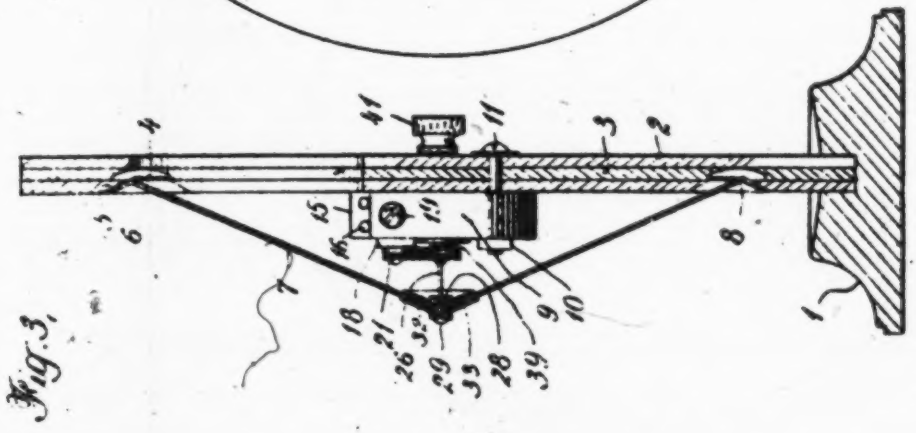

Fig. 3.

Certified to be the drawings referred to in the specification hereunto annexed.

New York this 8th March, 1926

APPLICANT

Marcus C. Hopkins

P/p Pennie, Davis, Marvin & Edmonds.

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Fig. 5,

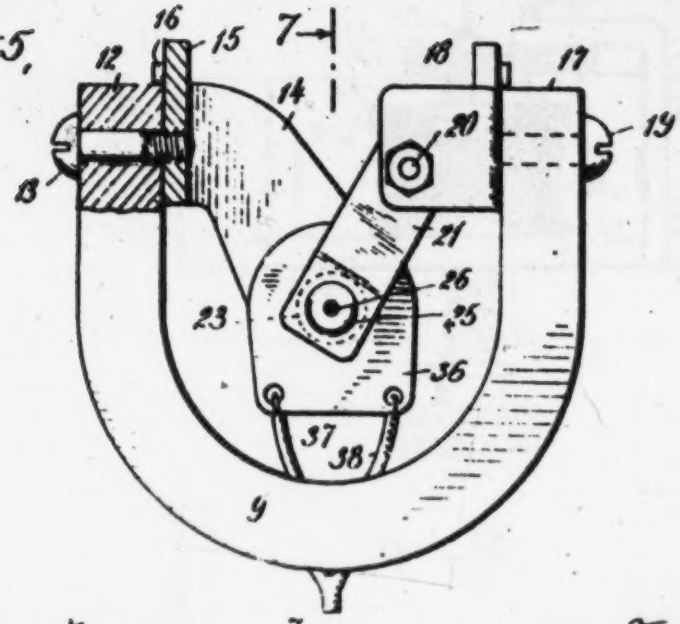


Fig. 6,

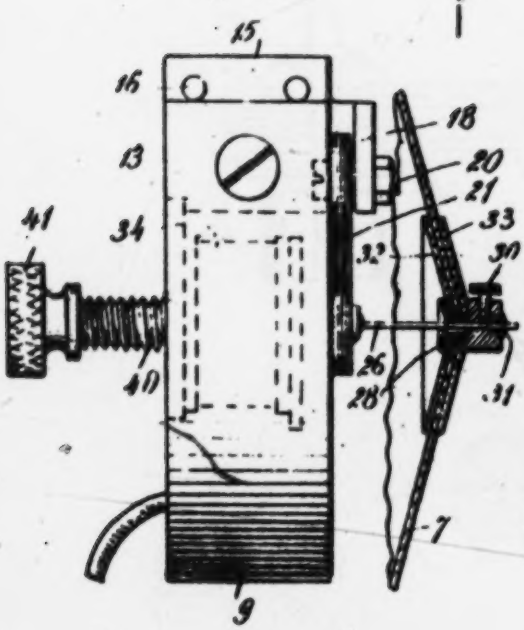
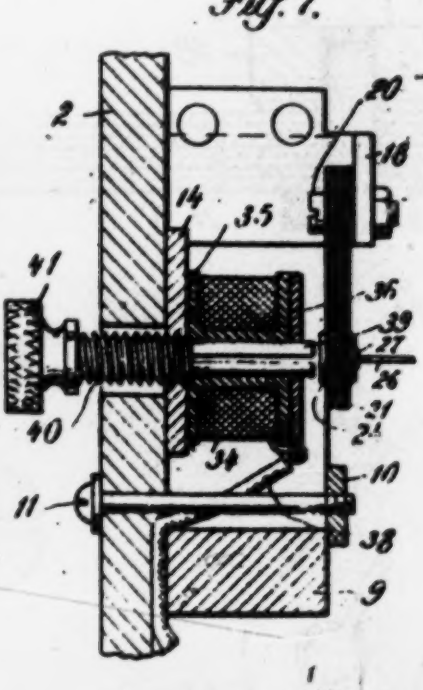


Fig. 7.



Certified to be the drawing referred to in the specification hereunto annexed.

New York, N.Y., U.S.A., March 8, 1926.

APPLICANT

Marcus P. Hopkins

By Connie, Davis, Mann & Edmonds

ATTORNEY

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Fig. 8

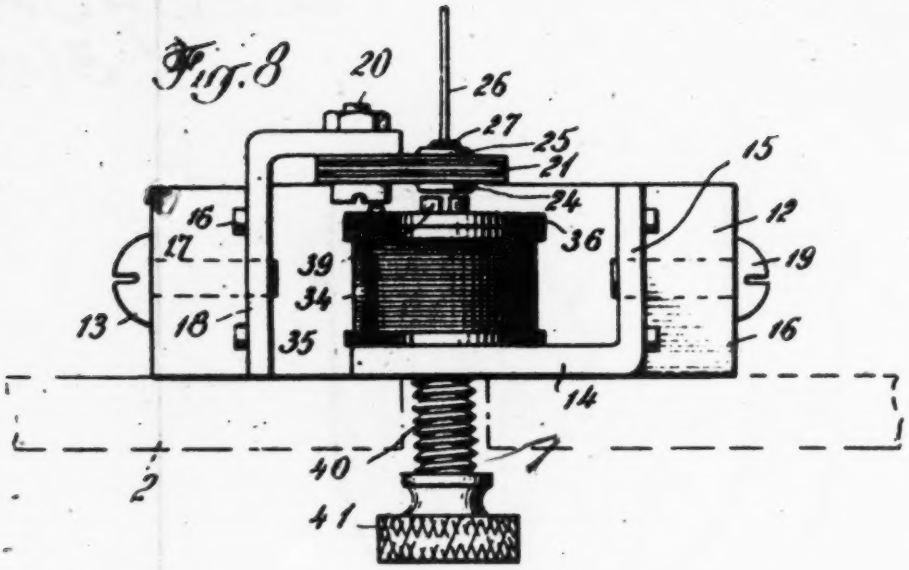


Fig. 9

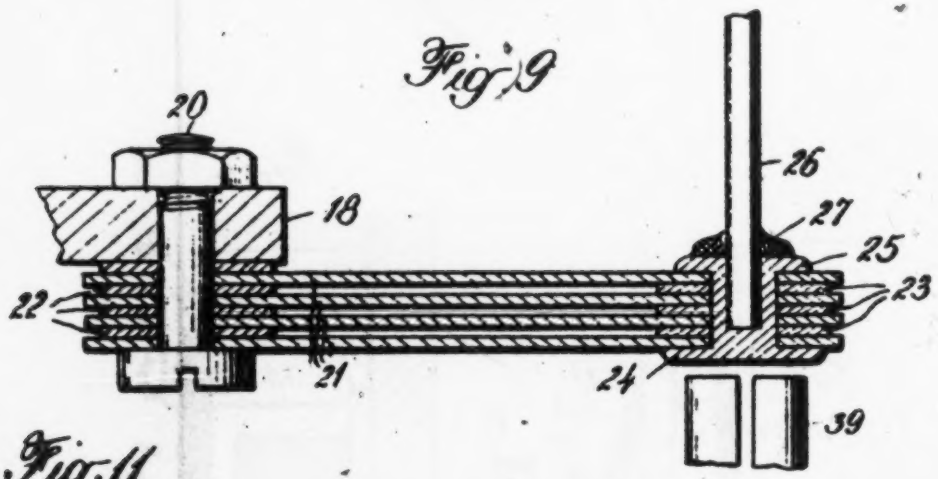


Fig. 11

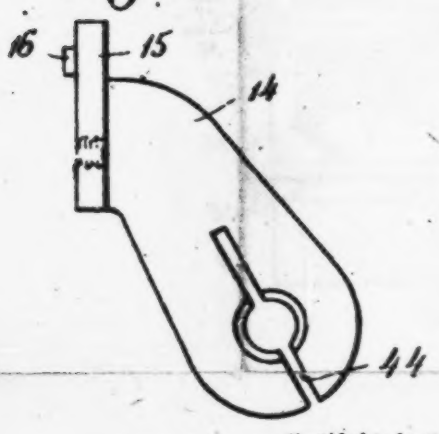
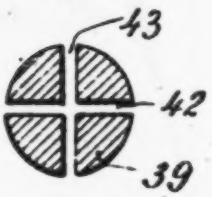


Fig. 10



Certified to be the drawings referred to in the specification hereunto annexed.

APPLICANT
Marcus C. Hopkins

New York, May 11th. March 8 1886

By Pennie Davis, Marvin & Edmonds
ATTORNEY

STIPULATION AS TO TRANSCRIPT.

(Filed February 28, 1930.)

IT IS HEREBY STIPULATED by and between the parties herein through their respective counsel, that the printed record on appeal in the United States Court of Appeals shall consist of the following papers and documents:

1. Bill of complaint.

2. Answer.

3. Amendment to answer.

4. Statement of the evidence in narrative form as agreed by the parties.

5. Plaintiff's Exhibits Nos. 1, 2, 5, 34, 35, 36.

6. Defendant's Exhibits Nos. 7, 11 to 11-L, 27, 28, 38, 39, 40, 41, 42, 43, 44.

7. The opinion of Honorable Hugh M. Morris, U. S. D. Judge.

8. Decree.

9. Notice of appeal and order allowing appeal.

10. Plaintiff's assignment of errors.

11. Citation.

12. This stipulation as to the contents of the record.

13. Clerk's certificate.

IT IS FURTHER STIPULATED AND AGREED that the following exhibits, namely, Plaintiff's Exhibits Nos. 3,

4, 31, 32, and Defendant's Exhibits Nos. 8, 9, 10, 10-A, 12, 12-A, 13, 13-A, 14, 14-A, 14-B, 15, 15-A, 15-B, 16, 20, 21, 23, 24, 25, 26, 29, 30, 31, 32, 33, 34, 35, 36 and 37 may be treated as physical exhibits and shall be produced in the Court of Appeals at the hearing and argument of this appeal.

(Sgd.) PENNIE, DAVIS, MARVIN & EDMONDS,
Attorneys for Plaintiff-Appellee.

(Sgd.) DARBY & DARBY,
Attorneys for Defendant-Appellant.

Dated: New York, N. Y.,
February 24, 1930.

ORDER APPROVING STIPULATION AS TO TRANSCRIPT.

(Filed February 28, 1930.)

And now, to wit, this twenty-eighth day of February, A. D. 1930, upon motion of Samuel E. Darby, Jr., Esq., of counsel for defendant-appellant, it is

ORDERED by the Court that the foregoing stipulation be and hereby is approved, and the clerk is hereby authorized to certify the transcript of record on appeal, prepared in accordance therewith, and to transmit the same, together with the physical exhibits therein mentioned, to the United States Circuit Court of Appeals for the Third Circuit, at Philadelphia, Pennsylvania.

(Sgd.) HUGH M. MORRIS, *J.*

CLERK'S CERTIFICATE.

UNITED STATES OF AMERICA,
DISTRICT OF DELAWARE, } *ss:*

I, HENRY C. MAHAFFY, JR., Clerk of the District Court of the United States for the District of Delaware, do hereby certify that I have carefully compared the foregoing writings with their respective originals, and find the same to be true and correct copies thereof, so full and complete as the same now remain on file and of record in my office, being a complete exemplification of the record and proceedings in the case of Lektophone Corporation v. Miller Brothers Company, No. 712 in Equity, pending in said court, made up in accordance with the stipulation of counsel for the respective parties and order approving same filed in said cause.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the seal of said court, at Wilmington, in said district, this twenty-second day of March, A. D. 1930, and the Independence of the United States of America the one hundred and fifty-fourth.

(SEAL)

(Sgd.) H. C. MAHAFFY,
Clerk.

UNITED STATES OF AMERICA,
Eastern District of Pennsylvania,
Third Judicial Circuit, set:

I, William P. Rowland, Clerk of the United States Circuit Court of Appeals, for the Third Circuit, do hereby certify the foregoing to be a true and faithful copy of the original transcript of record in the case of Miller Brothers Company, Appellant, vs. Lektophone Corporation, Appellee, No. 4379, on file and now remaining among the records of the said Court, in my office.

In testimony whereof I have hereunto subscribed my name and affixed the seal of the said Court, at Philadelphia, this 26th day of March, in the year of our Lord one thousand nine hundred and thirty and of the Independence of the United States the one hundred and fifty-fourth.

Wm. P. Rowland, Clerk of the U. S. Circuit Court of Appeals, Third Circuit. (Seal United States Circuit Court of Appeals, Third Circuit.)

SUPREME COURT OF THE UNITED STATES

ORDER ALLOWING CERTIORARI—Filed May 5, 1930

The petition herein for a writ of certiorari to the United States Circuit Court of Appeals for the Third Circuit is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

FILE COPY

MAY 24 19
CHARLES ELMORE C
CL

Supreme Court of the United States

OCTOBER TERM, 1929.

No. ~~272~~ 68

MILLER BROTHERS COMPANY,
Petitioner,

vs.

LEKTOPHONE CORPORATION,
Respondent.

JOINT MOTION TO ADVANCE AND ASSIGN THE CASE FOR HEARING WITH CASE NO. 520.

SAMUEL E. DARBY, JR.,
Counsel for Petitioner.

WILLIAM H. DAVIS,
Counsel for Respondent.

GALLO & ACKERMAN, Inc., 142 Liberty Street, 'Phones—Hitchcock 8078-9.